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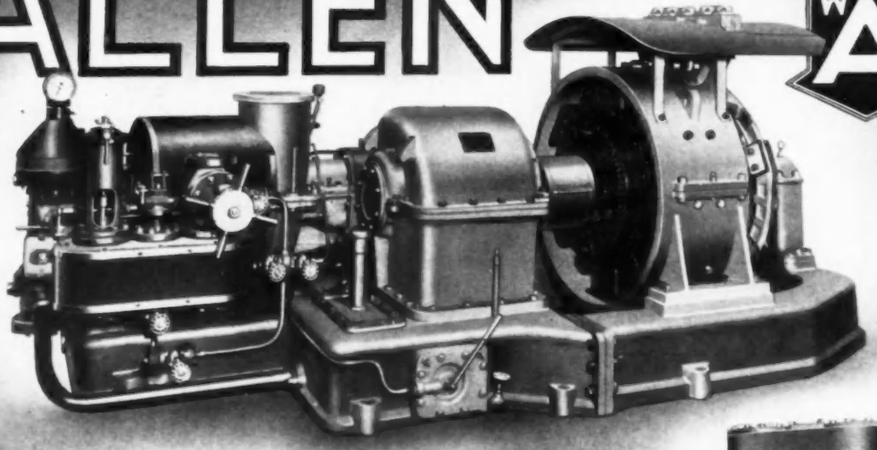

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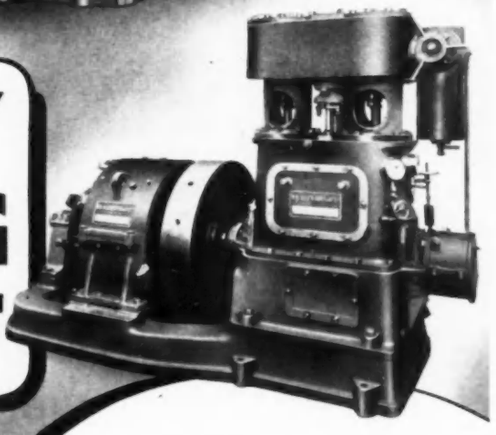

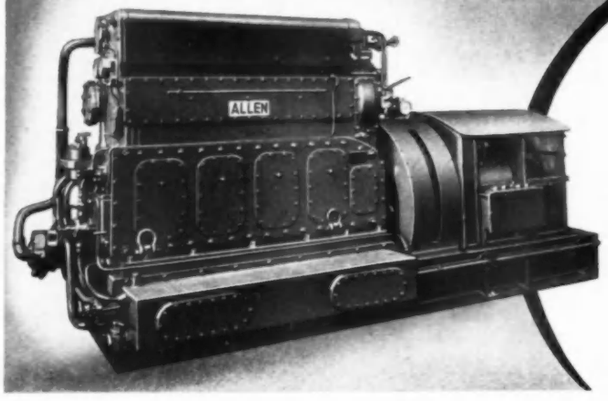

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CLAY AND SOIL MECHANICS.

By R. R. MINIKIN.

(Continued from page 243.)

A TERM much used in soil mechanics is hydrodynamic excess pressure, which means the pressure of the water in the pores during extrusion at any time. In theory, after an infinite time, when consolidation is complete, the value is zero. The hydrodynamic expression for reduction of volume due to the extrusion of pore water is

$$c\frac{d^2u}{dz^2}=\frac{du}{dt} \quad . \quad . \quad . \quad (6)$$

where

c = constant of consolidation depending on the permeability, the void ratio, and the rate of change of the curve of compression over the load increment,

u = hydrodynamic excess pressure in the capillaries causing the flow at any time t at a point z,

z = distance from the pervious strata (path of extruded pore water).

The rate of change of the compression curve is the slope of the line joining the points of the void ratio and pressure at the beginning and end of the increment. The consolidation is only complete when the clay particles are in conjunction one with the other; in other words, when the voids are completely exhausted of water.

Fig.8.

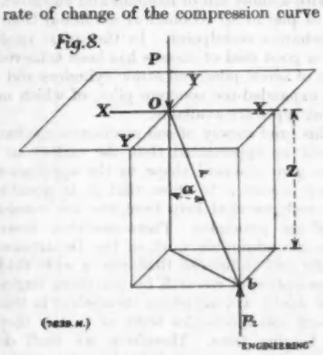
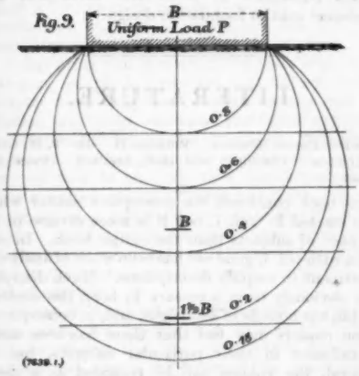


Fig.9.



The differential equation (6) may be integrated for several different sets of drainage conditions where

$$\mu=f(z)=f\left(\frac{\pi^2 c\,t}{4\,h^2}\right) \quad . \quad . \quad (7)$$

For our purpose it will be sufficient to confine attention to the fundamental term which forms the basis of the soil mechanics analysis, a dimensionless time factor, $\frac{c\,t}{h^2}$ which is common to all cases where μ is the degree of consolidation or the ratio

$$\mu=\frac{u}{u_0}=\frac{\text{hydrostatic excess pressure at time } t}{\text{initial hydrostatic pressure at any point}}$$

h = length of the drainage path.

Briefly, from the engineer's point of view, the above gives a lead to the appreciation of the great utility of the work which Gilboy, Casagrande and Terzaghi have put into the subject.

Conceding that laws of model similarity are applicable to the case and the reactions of the piece are representative of the whole, then we can utilise the time factor to practical advantage. It can be assumed that, to reach similar degrees of consolidation in material of identical characteristics but different thicknesses,

$$\frac{c\,t}{h^2}=\frac{c\,T}{H^2} \quad . \quad . \quad (8)$$

from which

$$T=\frac{H^2\times t}{h^2}.$$

Thus a laboratory specimen of clay 1½ in. thick takes 20 minutes to reach a consolidation of 75 per cent. The stratum from which the test piece was taken is 20 ft. thick and is sandwiched between pervious beds so that the drainage channels are similar to the test; void ratios are similar. Then the time required for the stratum of clay under equivalent loading to reach an equal consolidation is

$$T=\frac{(20\times 12)^2\times 20}{(1\tfrac{1}{2})^2\times 60\times 24}=355 \text{ days.}$$

From (7), in the initial stages of loading it can be shown that the degree of consolidation varies approximately as the square root of the time, $\sqrt{t}$. Now as consolidation implies a reduction in the length of the drainage path, say from h_1 to h_2, we can assume for practical purposes that the initial settlement of a loaded area will also vary as $\sqrt{t}$. Thus if such loaded area shows a settlement of ¼th in. in one month from the application of the load, then at the end of four months the total settlement will probably be ½ in., providing the degree of consolidation is not greater than 55 per cent. Above this limit the settlement slows up considerably (see Fig. 17 on page 262).

Fig.11.

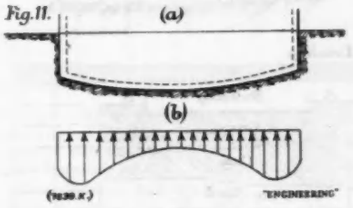
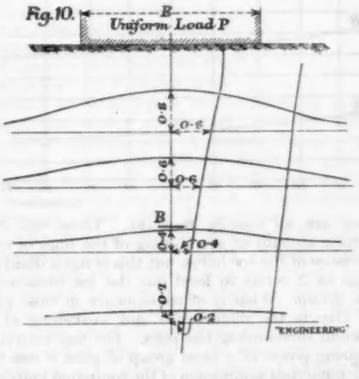


Fig.10.



The remaining part of the problem is the computation of the probable loads coming on the clay stratum. To arrive at this, use is made of Boussinesq's general expression for the distribution of stress in an elastic, homogeneous and isotropic solid (see Fig. 8),

$$p_z=\frac{3\,P\cos^5\alpha}{2\pi r^2} \quad . \quad . \quad (9)$$

where

P = point load at the origin O,

p_z = vertical component of stress at the point b at a vertical depth Z below the surface and radius r from the origin,

α = the angle between the vertical and the line joining the point b to the origin O.

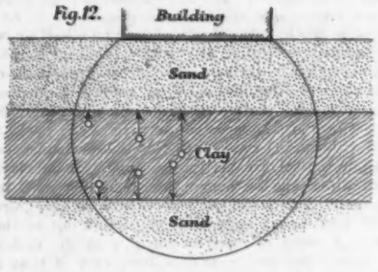
The expression (9) has been evaluated for many different forms of loading and shows a distribution of pressure in the soil as in Figs. 9 and 10. The bulbous curves show the lines of equal vertical pressure and give rise to the commonly used term "bulb of pressure." The distribution of the vertical stresses on the horizontal and vertical planes is shown in Fig. 10. It will be noted that the load causes appreciable stress in the ground to a considerable depth. At a depth of one and a half times the width of footing or building the maximum vertical stress is 20 per cent. of the applied load intensity. Published tables of vertical pressures calculated from the integration of the expression (9) for uniform loads can be obtained.

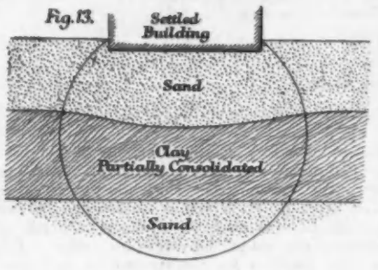
The above, in broad outline, is the mechanism of computation of the vertical consolidation of clays from which the settlement of a building may be evaluated. With the aid of modern portable equipment preliminary tests may be carried out in the field. A point of great importance in the design of foundations on or over a near clay is that a uniform load spread over an area, such as a rigid raft, gives rise to ground pressures which are not uniform over the same area. This may be inferred from Boussinesq's functions (see Figs. 8, 9 and 10). The point is, that the ground pressure opposing the uniform load is of greater intensity near the boundaries of the area, as shown in Fig. 11 (*b*). This is sometimes stated to be attributable to lateral flow; actually it is due to the vertical consolidation consequent upon the concentration of the pressure distribution. In such circumstances a rigid raft will not be an economical form to counteract such heavy stresses. On the other hand, a flexible raft, that is one which is thin enough to deflect without injury, will accommodate itself to the stresses and settle more in the centre than at the boundaries, as shown in Fig. 11 (*a*).

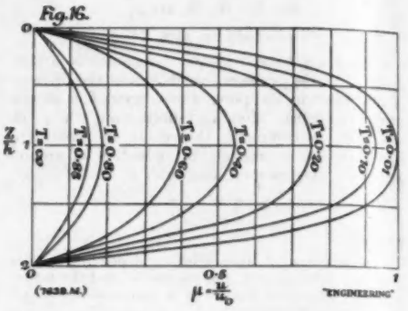
The capable designer will see in this characteristic of clay a ready means of effecting economy. A building sited as shown in Fig. 12, page 262, will cause a consolidation of the clay within the bulb of pressure shown. Neglecting the influence of the sand on the elastic settlement, the settlement of the building will continue until the equilibrium density for the loading is reached. This does not mean that complete consolidation is necessary, but it is probable that the layers near the drainage surfaces will approximate to complete consolidation while the middle portion of the stratum is under a lesser degree of consolidation. The curves of Fig. 16 show this clearly for different stages of consolidation. Thus the expression (6) is integrated for the average degree of consolidation over the vertical section of a thick clay bed. The probable distortion of the clay stratum is shown in Fig. 13, which also shows a uniform settlement of the building. Where the thickness of the clay bed varies, as shown in Fig. 14, it is obvious that the lengths of the drainage paths at one boundary of the foundations will be less than at the other. The time for equal consolidation will therefore be greater at one boundary than at the other if the loadings are equal, and the settlement of the building will not be uniform. Where a clay stratum is underlaid by impervious rock, as shown in Fig. 15, the length of the drainage path will be equal to the full depth of the layer. In Fig. 17, a diagram is shown of the probable settlements of a proposed building to be erected on strata indicated. These curves are calculated as described above and show that one corner of the face of the structure will settle in the first few years at a greater rate than the other. After four years there is no further increase in the differential settlement and the building will continue to settle to equilibrium density at a uniform rate. With such prior knowledge the engineer or architect can modify the design to correct the initial predicted tendency.

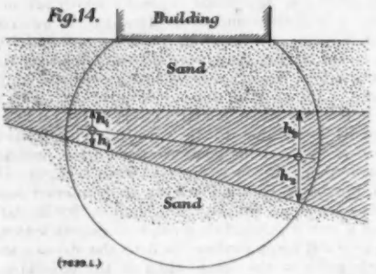
Driving piles into clay has the unfortunate effect of destroying the natural characteristics of the material from the soil mechanics point of view. The material is disturbed not only near the surface of the pile, but for some distance around. The act of driving causes a high increase in the hydrostatic head of the capillaries at the toe of the pile. As this occurs at each blow of exceedingly short duration, the water cannot escape naturally through the drainage channels and so disrupts the material. The most serious pile problem in clay arises on sites where the clay is soft and extends for a great depth. The driving resistance curve in such cases shows extremely little gain in an increase of depth and most erratic results are recorded. Where there is

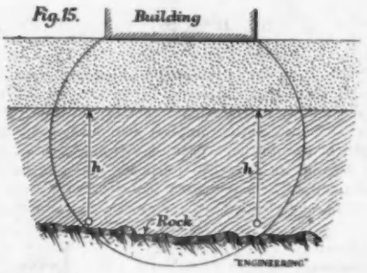
CLAY AND SOIL MECHANICS.

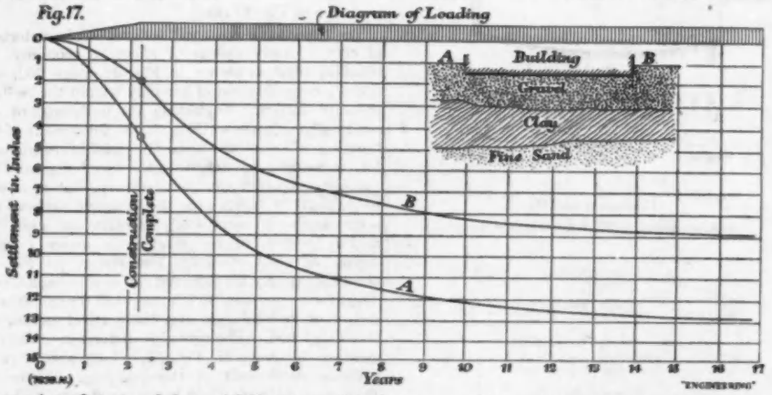












a succession of strata of clays of different qualities a penetration of, say, 20 ft., may show a greater resistance than one of double the depth. This often occurs where a sandy clay is underlaid by a softer clay. In driving it can be noticed that the resistance increases as the sandy clay is being traversed, but on nearing the softer clay a definite decrease of driving resistance becomes apparent (see Fig. 18, opposite). The author recalls that on one occasion several timber piles driven through 30 ft. of river bed to rock were looked for in vain by an early morning shift. Overnight the rising tide floated them and the ebb tide swallowed them up.

There is always a possibility of over-driving in clay. To avoid this, ample borings and samples of the strata should be taken by one of the several well known sampling test piles to some considerable depth below foundation. Soil mechanics enthusiasts so far do not admit of the applicability of pile-driving formulæ to clay strata. There is some prejudice in this attitude. What pile-driving formulæ do is to indicate the load that a pile will carry without undue creep through the ground, and not the absolute settlement of a structure due to sub-foundation consolidation. Even the eminent Terzaghi confounds this distinction. Soil mechanics principles still obtain in the sub-strata below the toe of the piles, as shown by the bulb of pressure diagrams in Fig. 19. The pile-driving formulæ are concerned with the load the pile can transmit effectively to the ground above this level.

The supporting value of a pile is due to the friction on the embedded surface of the pile and the direct pressure at the toe. If all piles of a group are driven to equal set and the embedded lengths do not vary much, then it is reasonable to assume they are all equally resistant. There will be a certain amount of overlapping of the lines of equal pressure of the toe bulbs, but this is not a disadvantage as it tends to level out the toe pressures of the group. What is of consequence in close piling in clay is the disturbance and weakening of the ground surrounding the piles. For this reason the bearing power of a close group of piles is less than the numerical summation of the computed individual resistances. Providing a reasonable evaluation of the bearing power of a group is made, little relative settlement need be apprehended, but as in the case of all foundations on clay the settlement due to the consolidation of the sub-strata must be considered. For this the group may be taken as founded at a few feet above the toe level, as indicated by the larger bulbs in Fig. 19.

In groups of piles supporting column footings the spacing is frequently as low as 2¼ diameters centre to centre. For 16-in. piles this would mean about 3 ft. 6 in. Suppose there are six piles in the group, each computed to support 30 tons. Then the stressed area of the clay at the toe level is approximately 40 sq. ft., and the average intensity of stress is 4½ tons per sq. ft., which is exceedingly high. It should not be forgotten that this is an active pressure in addition to the overburden pressure already imposed on the strata. Such a foundation in medium or soft clay would, perforce, show appreciable settlement. To counteract the concentrated effects of close piling for column footings, the author suggests a slight outward rake, say, 1 in 20 to 1 in 30. This would deepen the relative extent of the pressure bulb, but as the intensity is considerably reduced, there is a lesser degree of consolidation required for equilibrium density. In medium and soft clays it is an advantage to have a blunt nose to a timber or precast pile and shoes may be dispensed with. It is also good policy to drive with a short fall of hammer and cut down the length of pile to an economical minimum from the soil mechanics standpoint. In the softer qualities of clay a good deal of success has been achieved by the use of screw piles and screw cylinders and cast *in situ* expanded-toe concrete piles, of which many excellent types are available.

In this brief survey of soil mechanics mechanism it should be appreciated that the endeavour has been to give practical shape to the application of this new science; to show that it is possible to obtain real practical help from the due consideration of its principles. There remains, however, outside the admirable work of the Department of Scientific and Industrial Research, a wide field for the prosecution of research by practising engineers, who no doubt will accustom themselves in time to carry out soil mechanics tests as to-day they do direct bearing tests. Therefrom we shall derive added confidence in predictable settlement and economic gain in foundation design.

LITERATURE.

Electric Power Stations. Volume II. By T. H. Carr. London: Chapman and Hall, Limited. [Price 32*s.* net.]

This book continues the descriptive matter which was started in vol. I, but it is more diverse in the number of subjects than the earlier book. In contrast with vol. I, good use has been made of analytical treatment to amplify descriptions. Much discipline has obviously been necessary to keep the contents within the bounds of 440 pages, and, in consequence, some readers may feel that there has been undue curtailment in their particular subjects, but, in general, the volume can be regarded as a useful outline of current practice.

The book deals first with alternators, both high- and low-voltage generation being considered. The section on condensing plant emphasises, *inter alia*, the necessity for pumps operating in parallel to be designed to give stable and continuous characteristics; suitable curves are given. The divided condensers mentioned would be applauded by station engineers as a means of simplifying condenser cleaning. There is a definite trend towards vertical circulating-water pumps. Feed-heating systems are always a fascinating study, as the number of possible variations is considerable, and they can be readily explored by straightforward arithmetical methods. The author might have shown diagrams of the most up-to-date systems in this section. As regards make-up water, no modern base-load station would contemplate anything approaching 5 per cent., though the author covers this.

Transformers, reactors, switchgear, cabling and cables are discussed in three attractively written chapters. The portion on switchgear will repay careful reading. Mention is made of sectionalising gear, which is very important for faults, and the analysis of alternative switching methods is well done. There is a good description of the control room, in which the author points out wisely that

CLAY AND SOIL MECHANICS.

(For Description, see Opposite Page.)

Fig. 18.

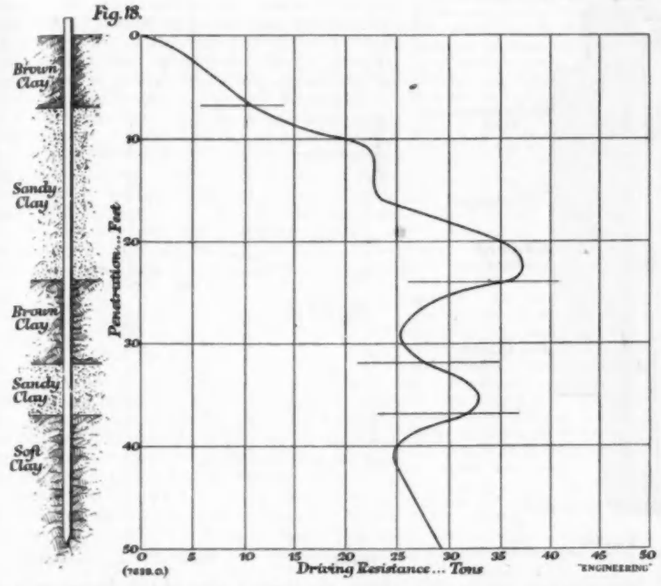
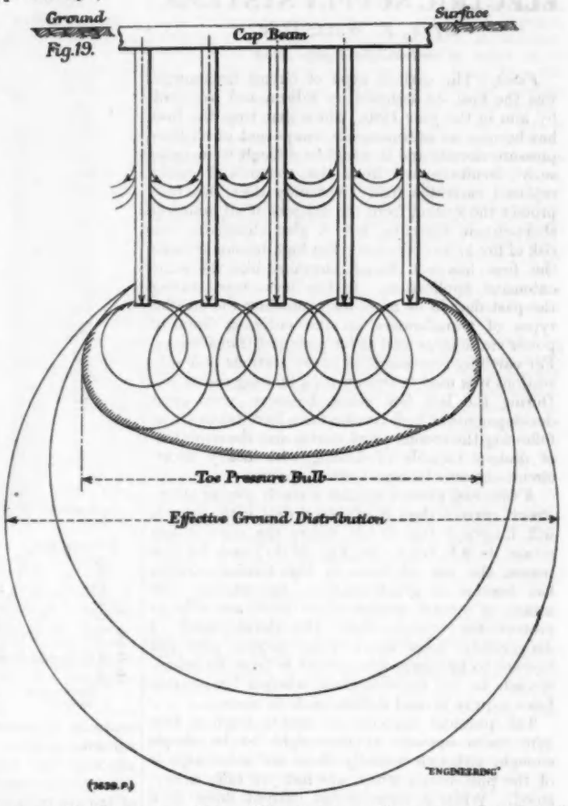


Fig. 19.



the layout, accessibility and grouping of the main instruments should be such that the control operator is not confused in emergency, but must permit of the operator reacting automatically in any combination of circumstances. This part of the book is obviously written with knowledge of conditions in large interconnected installations, and will help the mechanical engineer to appreciate the difficulties associated with these sections of power plant.

Lubricating and insulating oils rank high in the category of plant operation and an informative chapter deals with these, as well as with fuel oils. Station auxiliaries, electrical protective equipment and station lighting are also considered. The client's engineers, no less than the contractors, have an onerous task in ensuring that contractual obligations are observed, and for this reason the section on commissioning and testing of plant deserves careful study. Greater emphasis might have been placed on the use of condensate in boiling out new boilers, and on the importance of searching the units before commissioning.

The book closes with short chapters on organisation, costs, fire fighting and air-raid precautions. It is significant that the construction department is dealt with first in the duties of the power-station engineer. Any personnel scheme, however well developed, depends on the good will of the staff involved, as overlapping is sometimes unavoidable. More could have been said on power plant, and a chapter might have been allocated to the essential matter of materials, and their selection, testing and acceptance procedure. The book can be recommended to chemists who are interested in power plant, as well as to engineers.

The Theory of Plates and Shells. By PROFESSOR S. TIMOSHENKO. London: McGraw-Hill Publishing Company, Limited. [Price 42s.]

AT the beginning of the Nineteenth Century, the theory of plates occupied the attention of many scientists; as examples the mathematical investigations of Lagrange, Navier, and, particularly, of Poisson, may be instanced. In recent years, however, technical advances have called for a closer examination of all of the important stress problems for which they provided the foundations and during the past three decades, more especially, many highly advanced researches have been directed to finding simpler solutions of some of the more intricate of these problems. Unfortunately, the results of much of this work, and the interesting formulæ derived from it, are scattered among the numerous scientific and engineering journals. Valuable as these contributions often are, their practical utility is limited by the fact that they are published in many parts of the world and in several languages.

Engineers and designers who are familiar with Professor Timoshenko's previous books on the strength of materials, the theory of elasticity, and the theory of elastic stability will appreciate therefore this carefully planned treatise in which he presents concisely the many noteworthy theories and the most up-to-date researches and investigations on plates and shells. In it he analyses in detail the basic theories, the stresses and the deflections of rectangular and circular plates of both uniform and non-uniform thickness, with and without holes, and subject to various methods of loading and different edge conditions. Similarly, he investigates with great thoroughness elliptical and triangular plates, and, finally, he examines the cases of conical disc shells and spherical domes and of various other intricate shapes. The relevant formulæ are assembled in impressive array, with comprehensive lists of numerical factors. The essential results are presented in a series of tables, and special attention is given, also, to the construction of a number of useful graphs. The author reviews and discusses with characteristic clarity the many stress theories expounded during the past century by such international authorities as von Karman, Stodola, Keller, Nadai, Hencky, Föppl, Love, Galerkin and Meissner. Considerable space is devoted to the diagnosis of practical problems, and the application of the theory is supported by instructive numerical examples. Throughout, the volume bears the stamp of originality of thought and advanced research, and the helpful criticisms and suggestions with which its teaching is informed greatly enhance its value, especially from the designer's point of view.

Modern Assembly Processes: Their Development and Control. By J. L. MILLER. London: Chapman and Hall, Limited. [Price 13s. 6d. net.]

As an example of an effective assembly, this compact and practical book may be highly commended, for it presents in small compass the fruits of an extensive study of a subject, the literature of which is widely diffused among the pages of technical periodicals and the proceedings of institutions. It is much more than a mere compilation, however; the author has had a varied experience in devising and applying methods of assembly suitable for the construction of the small components which figure so largely in the manufacture of motor-car accessories and similar mass-produced fittings, and has been personally responsible for many of the processes and improvements that he describes. As a result, he has written a thoroughly practical work which is not only helpful in itself, but is calculated to stimulate the ingenuity of readers who may be confronted with similar production problems.

The processes discussed include the use of rivets, screws, bolts and nuts, soldering and brazing, press and shrink fits, and the various forms of welding. Particular attention is paid to copper brazing, a subject on which the author has specialised. The chapters on resistance welding also contain much material based on the author's own researches, and are illustrated by some photographs of sectioned welds which are well chosen to bring out the good or bad features of the particular examples. This applies also to the excellent line diagrams. Perhaps the most significant lesson to be drawn from the book as a whole is the influence that the production methods must exert on the design of small mass-produced components, and the importance of maintaining the closest collaboration between the two departments. The flexibility of the processes described is repeatedly demonstrated, and the need for a corresponding flexibility of mind in their application is stressed almost as frequently. It is probable that few manufacturers of small "gadgets" have at their command the laboratory facilities that the author has evidently enjoyed, for testing alternative methods and reducing them to quantitative values; but fortunately it is not essential to possess such equipment in order to profit from the experience that he has condensed into this serviceable volume.

THE CONTROL OF POWER IN LARGE INTER-CONNECTED ELECTRIC SUPPLY SYSTEMS.

By T. F. Wall, D.Sc.

(*Concluded from page* 223.)

Fuses.—The earliest type of circuit interrupter was the fuse, as designed by Edison and patented by him in the year 1880. Since that time the fuse has become an indispensable component of all low-pressure circuits and it would be difficult to imagine such circuits apart from the cheap and easily replaced cartridge fuse. Not only does this fuse protect the system from the dangers of all practical short-circuit currents, but it also eliminates the risk of fire in its operation. For high-tension circuits the fuse has not found anything like the same extensive application. It has been used during the past decade or more for protecting the smaller types of transformers on the outgoing lines of power stations, as well as for potential transformers. For earthing-reactances in power stations and sub-stations it is used in series with a limiting resistance. During the last few years, however, very great developments of high-tension fuses have taken place, following the corona-proof device and the evolution of designs capable of dealing with heavy short-circuit currents in high-tension systems.

A fuse can protect against a much greater short-circuit current than it can itself deal with, since it will interrupt the circuit before the current can attain its full value (see Fig. 64 (*b*)) and for this reason the use of fuses in high-tension circuits has become of great practical importance. By means of special devices these fuses are able to protect the system from the development of dangerously large short-circuit powers and can operate to interrupt the current in from 50 micro-seconds to 100 micro-seconds, whereas low-tension fuses require several milli-seconds to operate.

The physical sequence of events when a fuse wire melts appears at first sight to be simple enough, although actually there are some aspects of the phenomena which are not yet fully understood. When a short-circuit current flows in a fuse of fine wire and almost negligibly small mass, it vaporises the metal practically instantaneously and an arc forms between the two end fixtures of the wire. The problem of the fuse designer thus comprises the establishment of such conditions that the arc shall be quenched not later than the moment at which the current next reaches its zero value. In the very short time interval, therefore, of, perhaps, one ten-thousandth of a second, the ions and electrons which formed the conducting path of the arc must be compelled to re-unite and form neutral atoms or molecules; in other words, the path of the arc must become de-ionised so that the arc will be unable to re-ignite when the pressure across the fuse terminals rises to that of the line.

If a wire of the proportions which usually obtain in a high-tension fuse is held free in air and melted by an electric current, the consequent arc will not be quenched as the current passes through its zero value, since its path will be thickly strewn with ions and electrons, and these, under the influence of the voltage across the terminals, will be set in motion and so enable the current to start again. This effect may be maintained indefinitely and a persistent arc may become established, thus rendering such a simple form of fuse practically useless. In the practical form of fuses the de-ionisation of the path of the arc is effected in various ways which may be classified in three groups, as follows:—

(i) The fuse wire is surrounded by an insulating tube open at each end. When the fuse melts, the air inside the tube becomes very hot and the pressure produced by a vaporised wire blows the hot gases and vapour through the end of the tube. When the current reaches its zero value the arc will go out and the gas in the tube will contract so that the cold air will be sucked in at each end, and this cold air being electrically neutral will form a path of high insulation strength, so that the arc will be unable to re-ignite.

(ii) This group comprises the fully-enclosed type of fuse in which a metal cap fits over each end of the insulating tube and the fuse wire is stretched

POWER CONTROL IN ELECTRIC SUPPLY SYSTEMS.

Fig. 63.

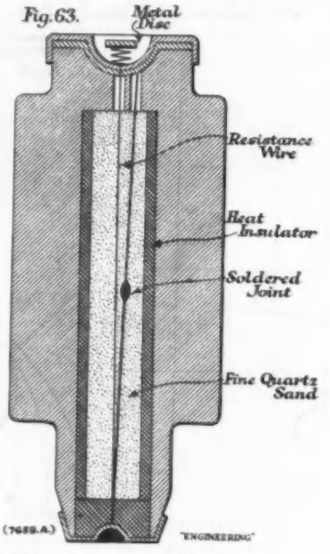


Fig. 64.(*a*)

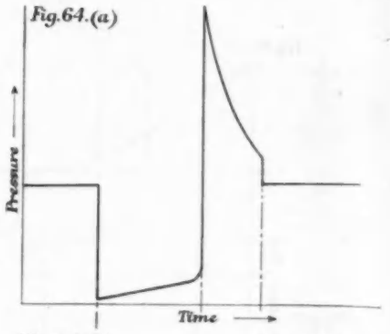


Fig. 64.(*b*)

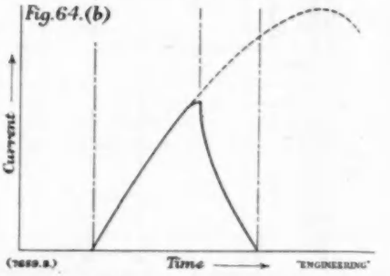


Fig. 65.

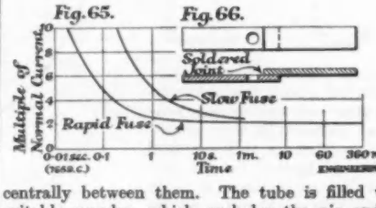


Fig. 66.

centrally between them. The tube is filled with suitable powder, which excludes the air and so prevents the deposition of molten metal on the sides of the tube. The de-ionisation of the path of the arc in this type of construction is due to the fact that the metal vapour and arc gases are forced through the numerous tiny channels which permeate the powder and the ions become fixed to the walls of these channels, while the increased gas pressure due to the arc current reduces the section of the arc and so limits its path and increases its resistance. This type of construction, therefore, produces an arc of constant length (in contrast with the fuses which comprise group (iii) referred to below). One form of construction of such a fuse is shown in Fig. 63. The outer container is a porcelain cylinder and is lined with a heat-insulating tube, the fuse wire being embedded in quartz powder. In order to indicate when the fuse has blown, the resistance wire, which will then have melted also, releases the small metal disc spring, so that the indicator disc will emerge and thus provide the signal that the fuse has operated.

In Fig. 64 (*b*) is shown the fuse current as a function of the time, from which it will be seen that in the case of a short-circuit on the system, the fuse will interrupt the circuit so rapidly that the current will not have time to reach its full value before the fuse melts. That is to say, the installation will be protected from the full action of the short circuit, and in this respect such a fuse is superior to any normal type of switch. In Fig. 64 (*a*) is shown the pressure across the fuse terminals corresponding to the current diagram Fig. 64 (*b*). The large excess pressure rise shown in this diagram is due to the very rapid fall of the current when the fuse melts, in consequence of which the inductance of the circuit will give rise to a high value of the induced e.m.f. $L\frac{di}{dt}$. In general, this pressure rise will not be dangerous and it can be kept down to a convenient value by suitably proportioning the switch unit.

The limit to the energy which such a fuse can deal with is fixed by the amount of heat energy which is released within the tube. If this is sufficient to produce sintering or melting of the powder filling, the binding effect of the channel walls on the ions ceases and a material is formed which is an electrical conductor of the second order, so that the fuse element will be destroyed without quenching the arc.

Silver wire is usually employed for fuses, as this metal has the advantage of a precisely defined limiting current-carrying capacity since the resistance rises very rapidly with the temperature. Silver, however, has a very high melting point (948 deg. C.) and it is desirable for normal running conditions that the temperature of the fuse body shall be kept as low as is practicable. The fuse wire, therefore, consists frequently of two parts soldered together. This soldered joint will melt at 240 deg. C., so that under normal conditions the temperature of the fuse must not rise above this value. Each fuse has a melting characteristic which specifies how long it takes for the wire to fuse at a given current. According to the shape of this characteristic it is usual to speak of a "rapid fuse" or a "slow fuse." Thus in Fig. 65 it is seen that both types of fuse have about the same limiting current capacity, while in the region of the excess current the slow fuse takes much longer to melt. Slow fuses would, therefore, be chosen for those cases in which a short period of overload may be allowed to occur without operating the fuse.

When the normal current is so large that strip must be used instead of wire, the characteristic of the fuse may be adjusted by forming a small hole near the soldered joint, as shown in Fig. 66. In this way, the limiting current is very little altered since the extra heating at the neck of the hole will have time to become dissipated, it being observed that silver has a very high heat conductivity. If, however, a heavy overload occurs, the narrow part of the strip near the hole will rapidly overheat and melt, and the greater the diameter of the hole the more rapid in action will the fuse become.

(iii) The fuses of this group operate on the principle of the oil-switch. A relatively short fuse wire is held in tension by a spring, so that when the wire melts the arc is drawn into a quenching medium, such as oil or a suitable powder. In this way, the arc is quenched when the current reaches its zero value, exactly as in the case of the oil switch, since the voltage across the terminals being then insufficient to break down the insulation between them. The limit to the energy with which such a fuse can deal is fixed by the rise of the internal pressure which the first half of the current wave produces due to the decomposition of the oil

in the intensely hot gases. For small currents the fuse wire must be so thin that destructive corona effects would develop at the surface if no provision were made to eliminate this danger. The action of the intense electric field at the surface of the wire produces a "corona discharge," and this gives rise to a powdering of the surface of the wire. Such corona action may be prevented by the provision of a spiral of resistance material surrounding the fuse wire, thus forming in effect a "Faraday cage."

High-tension fuses provide a relatively cheap alternative to switches and can be used when the more expensive switch would not be economically justifiable. Owing to the special features of fuses, they operate without noise and without ejecting gases and they are frequently installed in cases where their unusually high rupturing capacity of

Pressure, kV.	Normal Rated Amperes.	Pressure, kV.	Normal Rated Amperes.
3	400	30	40
6	200	60	15
10	100	100	6
20	50		

400 MVA or more is only used fractionally; that is to say, if a fuse comes into operation when the current has only reached a fraction of the value which it would attain if there had been no fuse (see Fig. 64 (*b*)), then that fuse can be said to have controlled the full power corresponding to the full short-circuit current. In this way, fuses can protect systems from the heavy dynamical and thermal effects which would be produced if the short-circuit current were allowed to reach its full value, and from this point of view fuses have an advantage over every type of normal circuit breaker. The accompanying table gives some idea of the range of high-tension fuses now available.

THE PROTECTION OF DOCUMENTS.

The lamination of documents with sheetings, for the purpose of mending broken paper and increasing the resistance to wear, has been practised for many years. The requirements are that the protective sheeting shall be stable, that the process shall be simple and reasonably cheap, and that the weight and thickness of the treated document shall not be unduly increased. The material most used for this purpose is "crepeline," a strong coarsely-woven silk fabric. Japanese tissue, a thin transparent and tough paper is also used to a large extent, as are other similar papers. Such sheetings are applied with an adhesive which is usually starch or dextrine, or a mixture of both.

Several years ago, the United States Bureau of Standards investigated the suitability of cellulose sheetings as protective coverings for the preservation of records. Trials were made of both the regenerated cellulose sheeting, such as Cellophane, and the cellulose-acetate sheeting. The latter was found to be the more stable of the two, and did not tend to wrinkle with ageing. Furthermore, the acetate type offered a decided advantage in that, being thermo-plastic, it could be applied by heat and pressure, without requiring an adhesive. The other type of cellulose sheeting in extensive use, namely, cellulose nitrate (celluloid), was found to cause deterioration of papers with which it was in contact. Protective treatments involving dipping the documents into solutions of cellulose derivatives, or spraying the solutions upon them, were tested, but the results were not satisfactory.

Acetate sheeting was found to possess a number of advantages over crepeline or tissue paper, according to the report. When heat and pressure are applied, the sheeting is forced into the pores of the paper, thus minimising the increase in the thickness of the document; and, if the operation is correctly performed, it is not possible to remove the protective covering without splitting the paper. The starch adhesive used with the crepeline and tissue makes documents more susceptible to attack by insects and fungi, whereas the acetate sheeting is protective in these respects. The acetate sheeting has the additional advantages that, being highly transparent, it does not obscure the written or printed record; it is easily cleaned with water; it resists the passage of gases which might cause deterioration; and it is quickly applied, thus facilitating the repair of documents. It permits photographic reproduction without loss of detail and is transparent to the ultra-violet and infra-red rays which are used to examine faded or otherwise illegible documents, whereas starch has an obscuring effect in these repects.

The preliminary investigation satisfied the Bureau that the process was feasible, and, in use by the National Archives of the United States, it was subsequently found to be eminently satisfactory. More recently, in view of commercial developments of the process, the Bureau decided to obtain more complete information. Six commercial firms and the National Archives co-operated in these further tests, the results of which have been recently published.* The research programme comprised (1) the testing of the acetate sheetings for the physical and chemical properties that appeared to be important with regard to laminating quality, resistance to wear, and stability; (2) the testing of the papers (furnished by the Bureau of Standards) for desirable properties that might be affected by the laminating process or by the sheetings; and (3) testing of the laminated papers for any impairment of these properties.

The sheetings were applied to the papers in various ways. Three of the co-operating organisations used plain sheeting applied with heat and pressure; one used an adhesive sheeting and then applied heat and pressure; and three used sheeting bearing an adhesive and applied it with pressure, but at ordinary temperature. The exact nature of the adhesives was not given, but it is known that synthetic resins and cellulose derivatives are used for the purpose. Both flat-bed presses and rolls were used to affix the sheetings. For affixing sheeting without an adhesive, the temperatures ranged from 150 deg. to 175 deg. C.; the pressures ranged from 300 lb. to 2,000 lb. per square inch; and the time required from 3½ minutes to 30 minutes. In the usual laminating process, the sheeting and the paper are pressed between polished metal plates, thus retaining the original glossiness and high transparency of the sheeting. A dull finish can be obtained by pressing a rough surface against the sheeting, but it lessens the transparency and the surface is not so easily cleaned.

The physical tests of the sheetings comprised the determination of thickness, weight, folding endurance, tensile strength, expansivity with change in moisture content, blocking temperature (the temperature at which the sheets begin to soften and adhere to each other), and exudation of the plasticiser. To determine the stability of the papers used, they were heated in dry air for 72 hours at 100 deg. C., a treatment which had been found to produce most satisfactorily the chemical changes likely to cause weakening of the papers by deterioration of the fibres. To test for the effect of light on the sheetings, they were exposed for 48 hours to the light from a glass-enclosed carbon arc, the temperature and humidity being kept normal. Samples of sheeting were also affixed to photographs and heated for 72 hours at 100 deg. C., to ascertain whether fading would be caused. No fading was observed, nor did the exposure to light cause deterioration. Except in one instance, the folding endurance was found to be greatly increased by the heat treatment. It was found that, as a group, the sheetings which contained no adhesive were more resistant to the heat treatment than those having adhesive; but, the report pointed out, the treatment imposed very severe conditions with regard to shrinkage and probable chemical reactions.

To determine whether extreme changes in moisture content would affect the bond between the sheetings and the papers, or cause a permanent increase in thickness, the laminated papers were subjected to three cycles of alternate humidification, at room temperature, with the moisture content in equilibrium, with relative humidities of about 5 per cent. and 95 per cent., respectively. Exposure to these extreme conditions did not alter the appearance of the laminated papers, nor was the adhesion of the sheetings impaired. There was no permanent increase in thickness. Tests were also made to ascertain whether the laminating process might cause distortion of signatures on documents, which might throw doubt on their genuineness. This possibility was of importance also with reference to maps and drawings. Writings on 12 different kinds of paper were photographed at a magnification of about 12 diameters and the samples were then laminated. The same portions of the writings were then photographed again, to obtain the same image size as before, and contact prints were made from both sets of negatives. When the negatives were registered in contact, it was found that the characteristics of the writing had not been significantly changed. The general conclusions drawn from the tests were that both the plain cellulose-acetate sheetings and those containing adhesive were suitable for use with permanent records, but, on the whole, the plain sheetings displayed superior stability. The sheetings had no adverse effect upon the stability of the papers.

* *Protection of Documents with Cellulose Acetate Sheeting.* By B. W. Scribner. National Bureau of Standards, Miscellaneous Publication M 168. Washington, D.C.; United States Government Printing Office. [Price 5 cents.]

DUAL-FUEL INTERNAL-COMBUSTION ENGINE.

Within the last year or two a large amount of research and production work has been done by Messrs. The National Gas and Oil Engine Company, Limited, Ashton-under Lyne, in connection with an internal-combustion engine which can be run on either oil or gas at approximately equal outputs. Apart from the question of the cost of oil for power and the possible difficulty of obtaining supplies in the present circumstances, the avoidance of waste of any kind of fuel is daily becoming more imperative, so that the development of a power unit which can operate on more than one fuel, for example, on surplus coke-oven gas, on methane from sewage-treatment plants, on producer gas from low-grade fuels, and so forth, all as alternatives to oil, which can, however, be used equally well when readily available, is one of considerable importance. The general problem was to design an engine to run on gas with the high compression ratio required in the compression-ignition oil engine, and from this arose the practice of igniting the gas charge by a small compression-ignited oil charge.

Some account of the dual-fuel engines made by Messrs. The National Gas Engine Company, is given below and is illustrated by Figs. 1 to 6, on pages 266 and 270. Before dealing with the constructional details, however, some particulars of the performance of an engine of this type may be given. For this purpose, we propose to make use of the report of a test made by Mr. W. A. Tookey, M.Inst.C.E., M.I.Mech.E., in June of this year. The engine in question was a four-cylinder dual-fuel high-compression engine running on the four-stroke cycle and of the firm's F.A.P. 4 type. The cylinders were 11-in. bore by 15-in. stroke and the designed speed was 428 r.p.m. with a full-load rated output of 200 brake horse-power for 12 hours in accordance with the British Standards Institution Specification. The compression volume ratio was stated to be 13·7 to 1. An external view of the engine on the test bed is given in Fig. 1. The internal construction is shown in Figs. 5 and 6, though these illustrate a six-cylinder engine. The ignition was effected by the injection of fuel oil, each cylinder having an independent C.A.V. fuel pump and injection nozzle. The quality of fuel oil delivered at each cycle was adjusted so that about 10 per cent. of the B.Th.U's consumed per brake horse-power per hour was contributed by the oil fuel. The proportion was checked by a gauge on the engine. The means for micrometric adjustment provided enabled variation to be readily made if and when necessary. Air was aspirated normally and the governing mechanism operated on the gas supply only.

The extent of the test is shown in Fig. 3. It lasted from 8.30 a.m. to 4.30 p.m., the engine being run continuously through this period. The time from 8.30 a.m. to 10 a.m. was occupied by warming and running up to load, and a 3-hour run was then made under a steady full-load output of 200 brake horse-power. After this test, the engine ran for 5 minutes down to three-quarter load, viz., 150 brake horse-power, at which rate it was kept steady for 45 minutes. A 15-minute change-over period followed, and after this the engine was run for 1 hour at an overload of 10 per cent., *i.e.*, with a steady output of 220 brake horse-power. After a 10 minutes change-over, the engine was again run steadily for 30 minutes at the full-load rating of 200 brake horse-power, and then, after a 15-minute change-over, was finally run for 30 minutes at half-load, viz., 100 brake horse-power. The curve in Fig. 3 shows the variation throughout the entire period of the test in the calorific value of the town gas used. The vertical scale indicates the gross calorific values in B.Th.U's per cubic foot. The readings plotted as black circles were obtained by means of a standard Junkers type calorimeter and those plotted as crosses by means of a dial calorimeter of the Sigma type, the two calorimeters operating in parallel. In using the data from the curve, the mean values of the portions relevant to the several tests were taken. These are given in Table I, page 266, the net calorific values having been calculated from the condensate drip of the Junkers calorimeter in the usual way. The rate of condensation was very uniform and was equivalent to 42 B.Th.U. per cubic foot.

The rate of gas consumption was registered by a Thorpe integrating rotary meter, a gas-expansion chamber being placed between the meter and the engine to avoid pressure fluctuation effects. Stop-watch readings were taken at 15-minute intervals throughout the test. The gas pressure was noted by a water manometer at the meter inlet and the temperature by a thermometer at the outlet. Samples of the gas were drawn from the supply main to the engines on six occasions between 10.50 a.m. and 4.15 p.m. These samples were analysed, the mean results being as follows:—CO = 6·5 per cent., CH_4 = 28·2 per cent., C_2H_4 = 2·86 per cent., H_2 = 44·7 per cent., and O_2 = 2 per cent. The inert gases consisted of 2·6 per cent. of CO_2 and 13·1 per cent. of N. Computa-

DUAL-FUEL INTERNAL-COMBUSTION ENGINE.

MESSRS. THE NATIONAL GAS AND OIL ENGINE COMPANY, LIMITED, ASHTON-UNDER-LYNE.

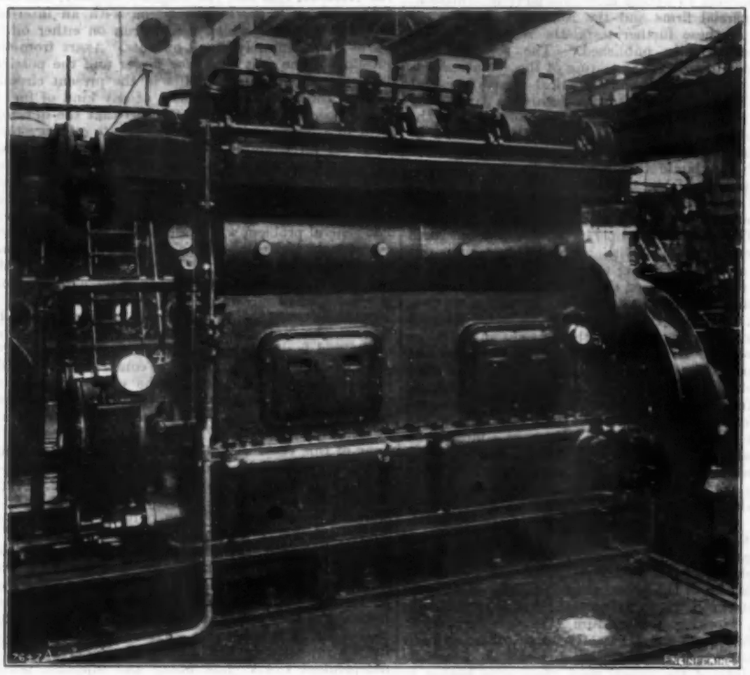


Fig. 1. 200-H.P. Engine on Test Bed.

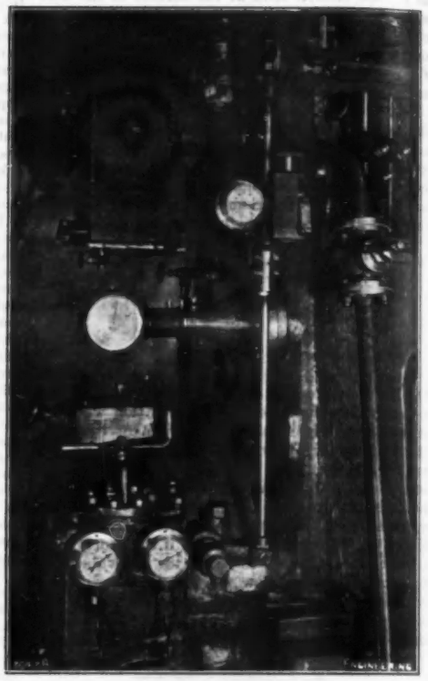
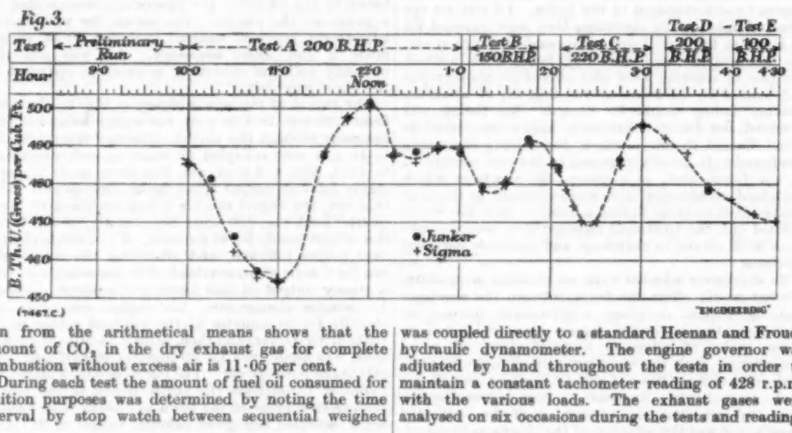
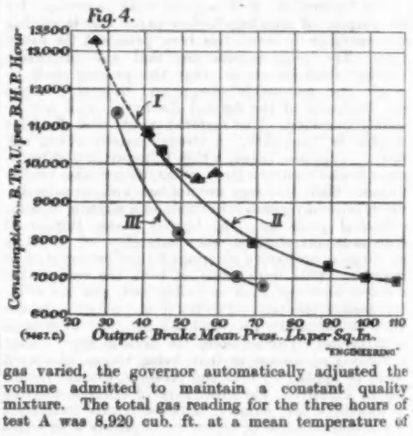


Fig. 2. Control Gear.





tion from the arithmetical means shows that the amount of CO_2 in the dry exhaust gas for complete combustion without excess air is 11·05 per cent.

During each test the amount of fuel oil consumed for ignition purposes was determined by noting the time interval by stop watch between sequential weighed quantities passing a mark in the sight-feed glass of the fuel tank. Lots of 1½ lb. to 4 lb. of oil were weighed as convenient to the load and the time interval between observations. The fuel was Pool Diesel Oil and a sample from the fuel tank tested in a bomb calorimeter had a calorific value of 19,660 B.Th.U. per pound. There was little actual variation in the oil consumption during the day, the quantity in lb. per hour ranging from 7·51 to 7·77. What deviation from uniformity there was might have been due to oil leakage past the fuel-pump plungers which was returned to the oil tank a few minutes earlier or later at each reading. For the determination of the brake horse-power the engine was coupled directly to a standard Heenan and Froude hydraulic dynamometer. The engine governor was adjusted by hand throughout the tests in order to maintain a constant tachometer reading of 428 r.p.m. with the various loads. The exhaust gases were analysed on six occasions during the tests and readings of the thermometer near each exhaust outlet were noted at intervals. Typical values were as follows:—Test A, full load, $CO_2 = 4·4$ per cent., $O_2 = 10·7$ per cent., $N = 84·9$ per cent., temperature 695 deg. F.; Test E, half load, $CO_2 = 3·2$ per cent., $O_2 = 12·8$ per cent., $N = 84$ per cent., temperature 536 deg. F. The engine performances in the tests is given in Table II.

With reference to Table II, it may be mentioned that the gas-meter readings during the full-load test A, showed that, as the calorific value of the gas varied, the governor automatically adjusted the volume admitted to maintain a constant quality mixture. The total gas reading for the three hours of test A was 8,920 cub. ft. at a mean temperature of 78 deg. F., and at a pressure of 7·5 in. of water above the barometer. Correcting this data, to the standard of 60 deg. F. and 30 in. of mercury, the consumption of gas works out to 14·36 cub. ft. per brake horse-power hour, which is equivalent to 6,900 B.Th.U. gross or 6,290 B.Th.U. net. At a mean rate of 7·72 lb. of fuel oil per hour used for ignition, there would be an additional consumption of 759 B.Th.U. gross or 708 B.Th.U. net. Thus the engine under full load consumed 6,900 + 759 = 7,659 B.Th.U. gross, or 6,290

Table I.—*Variation in Calorific Value of Gas.*

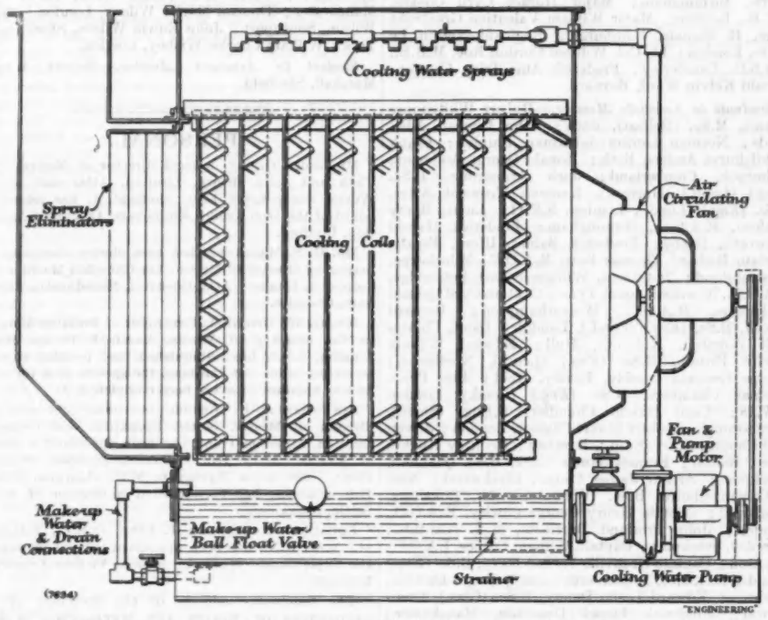
Test.	Brake Horse-Power.	Range of Gross Variation.	Mean Calorific Value in B.Th.U. per Cub. Ft.	
			Gross.	Net.
A	200	500/454	480	438
B	150	491/479	484	442
C	220	495/470	482	440
D	200	492/478	481	439
E	100	476/470	473	431

TABLE II.—Test Engine Performances.

Test.	Output.		Consumption in B.Th.U. per Brake Horse-Power Hour.					
			Gas.		Oil.		Total.	
	B.h.p.	B.m.e.p. lb. per sq. in.	Gross.	Net.	Gross.	Net.	Gross.	Net.
A	200	65	6,900	6,290	759	708	7,659	6,998
B	150	48·75	7,890	7,200	1,012	944	8,902	8,144
C	220	71·5	6,730	6,140	690	644	7,420	6,784
D	200	65	6,920	6,320	759	708	7,679	7,028
E	100	32·5	11,000	10,010	1,517	1,415	12,517	11,425

THE "PRESTCOLD" OIL COOLER.

THE PRESSED STEEL COMPANY, LIMITED, COWLEY.



+ 708 = 6,998 B.Th.U. net per brake horse-power hour, as shown in the last two columns of the table.

Comparing the results of the two full-load tests, A and D, it will be evident that the intermediate 10 per cent. overload test had not affected the engine detrimentally. Further, although the variations in the calorific value of the gas were more marked in the three-hour test A than in the half-hour test D, both at full load, the power output and fuel consumption were practically identical, viz., 7,000 B.Th.U. per brake horse-power hour on the net calorific value of the two fuels. To quote from Mr. Tookey's report, the result "is equivalent to over 36 per cent. thermal efficiency on the brake horse-power basis and represents a striking advance when compared with the performance of low-compression gas engines with magneto ignition." The results of the tests are plotted in Fig. 4, in comparison with tests on two other engines, also made by Mr. Tookey. Curve I shows the results obtained from a test made in October, 1923, on a six-cylinder vertical gas engine, with cylinders 13 in. bore by 14 in. stroke and developing 270 brake horse-power at 350 r.p.m. The gas used had about the same composition and calorific value as that referred to above. Curve II shows the results obtained from a test on a three-cylinder vertical gas engine in August, 1940. The cylinders were 4½ in. bore by 6 in. stroke, and the engine ran at 1,000 r.p.m. It had high compression and magneto ignition. These two engines were made by Messrs. The National Gas and Oil Engine Company and the results can, therefore, be fairly compared with those obtained with the dual-fuel engine plotted in Curve III.

An examination of Curve I shows that in this earlier type of engine the full-load rating was equivalent to about 55 lb. per square inch brake mean pressure, since the curve at that point shows that the lowest mean pressure had been reached. In Curve III, however, the brake mean pressure reached 71·5 lb. per square inch without showing any tendency to turn upwards, Curve III, of course, recording the rate of gas and oil consumption. The full-load rating of the two curves shows an increase of brake mean pressure from 55 lb. to 66 lb. per square inch, or an increase of 20 per cent. The rate of total fuel consumption on the net value at full load has been reduced from 9,600 B.Th.U. per brake horse-power hour in Curve I, to 7,000 B.Th.U. per brake horse-power hour in Curve III, an improvement of 37 per cent. Curve II shows that the smaller high-compression engine running at the higher speed attains similar maximum efficiency at higher ratings on the brake mean pressure basis. Mr. Tookey concluded his report by stating that, during the tests described above, "the engine ran regularly and without attention except at the time of changing the brake load when, as before mentioned, the hand regulation on the governor was varied to maintain the engine speed at 428 r.p.m. There can be no doubt that high-compression gas engines with oil injection for ignition purposes bring the gas engine into closer relation with the compression-ignition oil engine (Diesel type) and, in my view, the work done at Ashton-under-Lyne in this connection demonstrates that gas engines using home-produced fuel gas, sewage gas, or gas from hitherto unutilised sources will materially assist in meeting post-war industrial conditions."

Referring to the sectional views of the six-cylinder dual-fuel engine given in Figs. 5 and 6, these may be taken as generally representative of the four-cylinder engine tested. The construction of the cylinders, bed-plate, and running gear follows the makers' standard practice sufficiently closely to need no particular comment but some notes on the modifications attendant on the dual-fuel system may be given. In the first place it will be clear from the arrangement at the top right hand of Fig. 6 that a duplex manifold is provided for the inlet air and gas, the air passage being the inner one. Curved branches connect the manifold to the cylinder heads, these also having double passages. The air, being aspirated, does not require any control, but the gas supply is controlled by a butterfly valve in the gas passage, this valve being actuated by the governor through the lever system seen in Figs. 1, 2 and 6. In the two first-mentioned figures the governor lever is readily identified on the governor casing, and it will also be noticed that the vertical rod which controls the butterfly valve carries another mechanism about half-way up. This mechanism is for the purpose of giving motion to a rocking shaft running along the engine behind the two covers seen in Fig. 1 just below the air and gas manifold. It consists, briefly, of a bell-crank lever with one arm coupled to the rod and the other operating the shaft just referred to by means of a slotted link. The pin at the end of the last-mentioned arm is always at one end of the slot while the engine is running, being held in that position by a spring. A hand lever, seen in Fig. 2, enables the spring resistance to be overcome and the pin moved to the neutral position when it is desired to shut down the engine.

The rocking shaft actuates the fuel-pump racks. The fuel pumps, two of which are seen to the right of Fig. 5, are operated from the cam shaft in the manner shown in Fig. 6, the rocking shaft being distinguishable in this figure. The oil used for ignition purposes is, therefore, related to the gas supply through the governor system. The amount is constant throughout the load range, but it can be adjusted to suit the fuel supply by means of a micrometer screw on the rocking shaft gear. The proportion of oil being used at any time is expressed as a percentage of the total B.Th.U. consumed at full load by suitable graduation of the upper dial gauge seen in Figs. 1 and 2. The lower dial is, of course, that of the tachometer. It may be mentioned here that there is some little difference in the arrangement of the control gear in these figures, but this does not affect the general principles. The regulation of the oil supply mentioned above may be necessary from, say, a shortage of gas. Should the gas supply fail altogther, or if, for any other reason, it is necessary to run on oil alone, the main gas cock is shut and the micrometer control screwed right back. The fuel-control rod is then actuated by the governor in the usual way and the engine functions as an ordinary oil engine. On the other hand, should the engine, when running on gas, begin to "race," the governor rod will travel far enough to actuate the fuel-pump racks and the engine will be shut down completely from the consequent cessation of the "firing" oil.

The cylinders have individual heads, the disposition of the valves in which will be clear from Fig. 5 for the two left-hand cylinders. The right-hand valve in each case is the admission valve for the air and gas mixture, or for the air alone when the engine is running on oil only. The oil-injection nozzle is seen between the two valves. The left-hand valve is the exhaust valve, as might be inferred from the fact that the stem guide is water-jacketed. The small valve seen on the right-hand cylinder in Fig. 5, is the timing valve for the starting air. The air pressure is on the top of the valve, and as long as it is admitted the tappet rod and roller are held down so that the latter is in contact with the timing cam and the valve is opened at the necessary intervals and for the requisite time. A non-return valve is interposed between the timing valve and the cylinder. As soon as the engine is running on fuel the pressure air supply is cut off and the valve and tappet rod assembly, being no longer held down, is lifted by the spring seen near the camshaft, so that the timing mechanism is automatically disconnected. The starting-air supply pipe is seen in Fig. 1, with branches to three of the four cylinders. The starting of the dual-fuel engine is easy and this characteristic alone should appeal to users of producer gas, as there is no necessity to blow up the fire on the producer before starting, apart from the facts that fuel consumption is improved by at least 25 per cent. and an alternative fuel can be used should the necessity for doing so arise.

THE "PRESTCOLD" QUENCHING-OIL COOLER.

WHILE great strides have been made in recent years in the metallurgy of alloy steels and in methods of heat treatment to meet increasingly stringent specifications, little interest appears to have been directed to the improvement of quenching facilities. Highly-refined and stabilised quenching oils, possessing suitable viscosity and conductivity characteristics, are now available and although the importance of maintaining quenching baths at pre-determined temperatures, in order to obtain strictly consistent and uniform results, is generally recognised, the methods employed for controlling the temperature of the quenching oil are often unsatisfactory. Oil coolers of the shell and tube type, using water as the cooling medium, work well if means are provided for controlling the temperature of the oil, but unless river or well water is available in adequate quantities and at low pumping cost, they may be costly to run. Air coolers of the closed or open-circuit type are also employed, and while they are usually satisfactory in cold weather they are often unable to cool the oil sufficiently in hot weather. An oil cooler of the closed circuit type, the design of which is based fundamentally on that of the atmospheric evaporative water-cooling system commonly employed in refrigerating plant, is shown in section in the accompanying illustration. This equipment appears to possess several distinct advantages. It is a compact piece of apparatus occupying little floor space, the water consumption is very small, and the installation and maintenance of the cooler are simple. Above all, thermostatic control equipment maintains the temperature of the oil in the quenching bath within close limits. The name, "Prestcold," has been given to the oil cooler, which has been developed recently by Messrs. The Pressed Steel Company, Limited, Cowley, Oxford, and the distributors are Messrs. Wild-Barfield Electric Furnaces, Limited, Watford, Hertfordshire.

The oil cooler consists of a heavy-gauge galvanised sheet-steel casing of all-welded construction, mounted on a shallow mild-steel plate water tank, the whole being arranged on a frame of rolled-steel channels. Inside the casing is fitted a bank of galvanised seamless steel cooling coils connected by headers, through which the oil is circulated at a suitable velocity by means of a pump. At one end of the cooler, and shown on the right in the illustration, is arranged an axial-flow fan, which directs air on to the cooling tubes. The fan is driven, by a Vee-belt, from a motor mounted below it on an extension of the under-frame. The same motor drives a small centrifugal pump which raises water, through a strainer, from the tank in the base and forces it through a series of atomising nozzles arranged at the top of the cooler. The water from the nozzles falls in the form of fine spray on to the surfaces of the oil-

cooling coils and keeps them continually wet. Spray eliminators, shown on the left in the illustration, cause the atomised spray carried to the end of the casing by the air stream to be deposited and the water drains back into the tank, thus keeping the water consumption down to a minimum. As the air driven through the casing and over the cooling coils is not saturated with moisture, it is able to take up water-vapour by evaporation, and the latent heat of evaporation of the water is used to remove heat from the oil circulating through the coils and also to maintain the water at a practically constant temperature. The water in the tank in the base is kept at a constant level by means of a ball-float valve which admits make-up water from the mains. Trunking can be attached to the saturated-air exhaust outlet to carry the exhaust outside the heat-treatment shop.

Thermostatic-control equipment automatically starts up or stops the operation of the oil cooler according to the temperature of the oil in the quenching bath. Automatic steam or electric heating apparatus for warming the oil in cold weather, in order to bring the quenching bath up to the desired temperature after a shut-down and before quenching begins, is also supplied if required. Six standard sizes of Prestcold oil coolers have now been developed. These range from 25,000 B.Th.U. to 250,000 B.Th.U. per hour capacity, the capacities being based on the cooling of oil from 120 deg. F. to 95 deg. F., in summer weather under mean maximum conditions of 67 deg. F. wet-bulb temperature and 80 deg. F. dry-bulk temperature. Moreover, the capacities of the coolers can be varied by altering the flow of the air and of the oil. In addition to their use in metallurgical heat-treatment shops, the oil coolers may be usefully employed for such purposes as the cooling of transformer and Diesel-engine oils.

BRITISH STANDARD SPECIFICATIONS.

The following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Density-Composition Tables for Hydrochloric and Nitric Acids.—Two new specifications containing sets of tables giving the density compositions for aqueous solutions of nitric acid and of hydrochloric acid have recently been issued. The publication relating to nitric acid is designated No. 975-1941, and that dealing with hydrochloric acid, No. 976-1941. It may be recalled that similar tables have already been issued for sulphuric acid (No. 753), sodium chloride and calcium chloride (No. 823), and caustic soda (No. 824). These density-composition tables have been prepared primarily for use in conjunction with British Standard density hydrometers, dealt with in specification No. 718. The hydrometers and tables together provide a simple means of determining the strength of any aqueous solution of the chemical to which they relate or as a guide in making up a solution of given strength. Although the tables are primarily intended for use in connection with British Standard density hydrometers, they may be used in conjunction with any method of determining density as the compositions of aqueous solutions of acid have been correlated directly with the density. It is pointed out that the Institution will welcome suggestions for the preparation of tables for other liquids of industrial importance. [Price 3*s.* 6*d.* net each, or 3*s.* 9*d.* postage included.]

Building Bricks.—A war-emergency revision of specification No. 657, which has just been issued, deals with the dimensions of common building bricks. It implements the agreement reached by the Director of Bricks of the Ministry of Works and Buildings in collaboration with the industry on the sizes of bricks to be standardised for the duration of the war. The original issue of the specification, which appeared in January, 1936, related to clay bricks only, but the publication has now been extended to cover all building bricks, whether of clay, sand-lime or concrete, and including composition bricks. It is specified that all bricks shall be 8½ in. long, 4 1/16 in. wide, and either 2½ in. or 2⅞ in. deep. Modifications to plant and equipment in order to conform to the standard depth is comparatively easy, but it is realised that there may be some difficulty regarding the modifications to conform to the dimensions for length and width. A note in the foreword explains that, where such modifications are necessary they need only be effected when the replacement of equipment has to be made. Conformity to the standard depth, however, becomes operative immediately. A note in the specification also states that its requirements do not apply to bricks produced in Scotland. [Price 1*s.* net or 1*s.* 3*d.* postage included.]

INSTITUTION ELECTIONS.

Institution of Mechanical Engineers.

Associate to Associate Member.—William James Barrie, Birmingham; Major Horace Cyril Cookes, R.T.R., London; Major William Valentine Greatraks Fuge, R. Signals, Edinburgh; Reginald Nelson Le Fevre, London; Lt.-Col. William Gordon Roe, M.B.E., R.A.S.C., Camberley; Frederick Aine Trim, Chester; Donald Kelvin Ward, Burnley.

Graduate to Associate Member.—Robert Whitehouse Adams, M.Sc. (Belfast), Bath; John Duncan Adie, Leeds; Norman Lenton Ackerman, Shipley; Frank Middlehurst Anders, Bath; Ronald George Anderson, Holmrook, Cumberland; Jack Armstrong, B.Sc. (*Eng.*) (Lond.), Harrow; Kenneth Troward Arter, B.Sc. (*Eng.*) (Lond.), London, S.E.11; Lieut. Harry Ashford, R.A.O.C., Birmingham; Frederick Harold Ashworth, Derby; Frederick Baines, Ilford, Essex; Captain Richard Thomas Barr, R.A.O.C., Milnthorpe, Westmorland; 2nd Lieut. William Stuart Betteridge, R.A.O.C., Newcastle-upon-Tyne; Captain Cyril Oswald Blakemore, R.A.O.C., Wolverhampton; Bernard Boxall, B.Sc. (*Eng.*) (Lond.), London; Lieut. Charles Hall Boynton, R.A.O.C., Hull; Edward William Martin Britain, B.Sc. (*Eng.*) (Lond.), Northwich; George Leonard Cassidy, Bexley, Kent; Eric Percy Thomas Chambers, B.Sc. (*Eng.*) (Lond.), London S.W.18; Cecil Haydn Chandler, B.Eng. (Sheff.), Farnborough; Robert Stuart Chasser, London; Jewan Lall Chopra, B.Sc. (Edin.), Bombay; Geoffrey Hughes Clare, Bolton; Francis James Clark, B.Sc. (Manch.), Stockport; Arthur James Clarke, Blackwood; Neal McCalgan Clarke, B.Sc. (Witwatersrand), Boksburg, Transvaal; Captain Henry George Cowley, R.A.O.C., London; John Crosland Darricote, M.A. (Cantab.), Romiley, Stockport; Captain William Davies, I.A.O.C., Poynton; Captain Granville Vernon Davy, B.Sc. (*Eng.*) (Lond.), R.A.O.C., Teignmouth; Philip Roger Dawson, Wisbech; Edward Leslie Denny, B.Sc. (Glas.), Dumbarton; Frederick Lionel Donnison, Manchester; Philip Gerard Duff, Rugby; Robert James Eldred, B.Sc. (*Eng.*) (Lond.), Manchester; Lionel Harvey Elford, London, W.5; Hugh Ford, Ph.D., B.Sc. (*Eng.*) (Lond.), Northwich; John Slade Fox-Andrews, Bath; Albert Victor Francis, Oldbury; Arnold Freedman, London, S.W.15; Donald Garside, Halifax; George Edgar Gott, Hayes, Middx.; William Graham, B.Sc. (Glas.), Singapore; Edward Granger, London, S.E.18; 2nd Lieut. John Richard Greene, B.A. (Cantab.), R.A.O.C., Renfrew; Norman Caley Haigh, Rugby; Thomas Gollan Henderson, Buckhaven; Lieut. Henry John Carwardine Hill, I.A.O.C., Risalpur, India, Eric Hood, Welling, Kent; Captain Kenneth Charles Cassels Hunter, R.A.O.C., Egham; Maurice Frederick Hurdle, Burton-on-Trent; Frank Ives, Birmingham; Ronald Guy Jarvis, B.Sc. (*Eng.*) (Lond.), Derby; Lieut. Edward Henry Jee, R.A.O.C., Reading; Leslie James Kastner, M.A. (Cantab.), M.Sc. (Manch.), Manchester; William James Kelsey, Birmingham; Howard Joseph Kemp, Coventry; John Norman King, B.A. (Cantab.), Manchester; Harold Robert Layfield, Twickenham; John Lomax, M.Sc. Tech. (Manch), Dundee; Ewen Gordon McEwen, B.Sc. (*Eng.*) (Lond.), Huddersfield; John Christopher McLaughlin, Dumbarton; Malcolm John McMaster, Johannesburg; Edward George Henry Mathews, Calcutta; Herbert John May, Greenhithe; Major Thomas Frederick Morse Moore, R.A.O.C., Braunton; Alfred Alan Morton, Bristol; Douglas Colin Mosby, London; Lieut.-Colonel John Bertram Muriel, B.A. (Cantab.), Whitehaven; Alexander Charteris Murray, Billingham-on-Tees; Reginald Naylor, St. Helens; Russel William Newson, Oxford; Major John Nicholson, M.C., R.A.O.C., Leeds; Thomas Richard Joe Oakley, Teddington; Arthur Herbert Sebastian Oddy, B.Sc. (*Eng.*) (Lond.), Darlington; Lieut. Frederick William Oliver, R.A.O.C., London; Terence Andrew O'Neill, Crewe; George Parkin, B.Sc. (Manch.), Derby; George Pate, B.Sc. (Glas.), Carnoustie; James Donald Petty, B.Sc. (*Eng.*) (Lond.), Annan; Cecil Gordon Phillips, Southampton; Harold Stanley Prosser, B.Sc. (B'ham), Birmingham; Ernest Raymond Radway, Swindon; Lieut. James Ivan Raj, I.A.O.C., Motherwell; Kenneth George Reeves, B.Sc. (*Eng.*) (Lond.), Worcester; Thomas Collinson Ridings, Bradford; Fred Rigney, Manchester; Harry Maurice Riordan, London; Gilbert Briscoe Robinson, Birmingham; Captain Charles Francis Jocelyn Ryan, B.A. (Oxon), R.E., Longmoor; Captain Harold Savidge, R.A.O.C., Coventry; Andrew Sharp, London; Oliver Joseph Henry Simon, B.A. (Cantab.), Stockport; Arthur James Smith, Bexleyheath, Kent; Richard Ewell Smith, B.Sc. (*Eng.*) (Lond.), Derby; James Southern, Bolton; Lieut. Alexander Hall Spalding, I.A.O.C., Blackley; Lieut. Gerald Oliver Stevenson, R.A.O.C., Cheadle; Frederick William Stone, Nottingham; Bertram Ernest Strachan, Wetherby; Frank Alan Stratton, Manchester; Arthur Edward Taylor, London; John Stephen Thomas, Farnborough; Denis George Tobin, London; William Lloyd Tomkins, Pontypridd; Edward Reginald Varney, Derby; Harold Edward Walker, B.Sc. Tech. (Manch.), Portsmouth; George Walters, Darlaston, Staffs; Theodore Weiner, London; Lieut. Robert Welbury, Newcastle-upon-Tyne; P.-O. Eric James Wells, R.A.F.V.R., Manchester; Duncan Marlor Wilcox, London; Frank Wilson, Southport; John Edwin Wilson, Stockton-on-Tees; William Charles Wisbey, London.

Student to Associate Member.—Robert Watson Marshall, Sheffield.

PERSONAL.

Mr. John Green, a local director of Messrs. Thos. Firth and John Brown, Limited, Atlas and Norfolk Works, Savile-street East, Sheffield, 1, has joined the board of the Iron Trades Employers' Insurance Association, Limited.

Mr. G. S. Maginness has been elected chairman and managing director of Messrs. The Churchill Machine Tool Company, Limited, Atlantic-street, Broadheath, Altrincham, Cheshire.

Mr. G. W. Mitchell, Controller of Building Materials in the Ministry of Works, Lambeth Bridge House, London, S.E.1, has relinquished that position in order to return to his own business, the specific task for which he was appointed having been completed.

Sir Francis L. Joseph, chairman and managing director of Messrs. Settle, Speakman and Company, Limited, Stoke-on-Trent, has been appointed a director of Messrs. Berry Hill Collieries, Limited, Stoke-on-Trent. Sir Adam Maitland, M.P., chairman of Berry Hill collieries, has been elected a director of Messrs. Settle, Speakman.

Squadron-Commander J. Bird, O.B.E., F.R.Ae.S., M.I.N.A., R.N., has been appointed general manager of the Supermarine Works of Messrs. Vickers-Armstrongs Limited.

The temporary address of the Secretary of The Institution of Mining and Metallurgy is now: The Royal School of Mines, London, S.W.7. All library inquiries, including applications for the loan of books by post, should now be addressed to: The Librarian, The Institution of Mining and Metallurgy, Mill Close Mine, Darley Dale, near Matlock, Derbyshire.

Mr. A. G. Beaver, managing director of the Sun Electrical Company, Limited, has been elected President of the Electrical Wholesalers' Federation, the war-time address of which is 5, Vicarage-road, Henley-on-Thames, Oxon. Mr. Beaver served as president of the Federation in 1922.

Messrs. C. S. Meik and Halcrow, Alliance House, Caxton-street, Westminster, London, S.W.1, have taken into partnership Mr. H. D. Morgan, M.Sc., M.Inst.C.E. As from October 1 the name of the firm has been changed to Messrs. W. T. Halcrow and Partners.

Mr. Robert J. Norton, a director of Messrs. Potters, Limited, of Yeovil and Loughborough, has been compelled, for health reasons, to retire from active duty with the company after 25 years' service. Mr. Norton, however, remains a director.

Mr. G. H. Tilly, B.Sc., assistant superintendent for lifts and escalators, London Passenger Transport Board, has retired owing to ill health. He has been succeeded by Mr. I. W. Standring, A.M.I.E.E., who has been made an officer of the Board. Mr. E. T. Brook, superintendent of rolling stock (railways), has relinquished his railway responsibilities, for the time being, but is remaining with the Board as an officer and will continue to discharge various official duties. Mr. J. A. Wilks at present second assistant superintendent of rolling stock, has been appointed acting superintendent of rolling stock (railways).

Clay and Soil Mechanics: Erratum.—We regret that in the first part of Mr. R. R. Minikin's article on "Clay and Soil Mechanics," published in our issue of September 26, the value of Poisson's ratio for soft metals was given as "about 0·26," on page 241, 25 lines from the top of the centre column. The value intended was

$$\frac{1}{2 \cdot 6} = 0 \cdot 38.$$

War-time Factory Lighting: Addendum.—In the article published on page 37, *ante*, dealing with the subject of "blacking-out" and admitting daylight to a factory by means of cable-operated sliding shutters, reference was made to the winches employed for the operation. These winches, we are now informed, were supplied by Messrs. The London Electric Firm, South Croydon, Surrey, and were of the firm's precision worm type, with drums having a divided barrel. When rotated the drum winds up one strand of the cable, connected to the sliding shutters, on one section and pays out the other strand simultaneously from the other section, thus traversing the shutters positively when either opening or closing.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—A concession which should prove of great value to the Welsh coal trade has just been announced by the Mines Department. This was the decision to place the price of coal sold for coastwise shipment on the same level as that sold for export. For a long time local colliery owners have been seeking to obtain this concession without success. As a result of the growing demands of the inland trade, the coastwise shipments have increased in importance, especially since they have helped very materially to relieve the strain placed upon the railways. With inland business forming the bulk of the present trade the decision to raise the coastwise prices to the export level will mean a difference in some cases of as much as 2*s.* per ton to the local collieries. On the average it has been estimated that the concession will mean an extra 1*s.* to 1*s.* 6*d.* per ton. It was only a month ago that the price of coals sold as bunkers for use on vessels plying in the coastwise trade were brought up to the same level as those ruling for ships trading to foreign destinations. There is again a brisk demand on the steam-coal market, from inland users. The amount of new business that could be accepted, however, was still limited owing to the fact that collieries generally had already sufficient business on their books to provide a steady outlet for the bulk of their outputs for some time to come. Consequently the occasional odd parcels of the more favoured kinds, offered for early delivery, were taken up at high prices. The general tone was very firm. The best large descriptions were moving off steadily under existing contracts, and there was a sustained request for sized sorts. Bituminous small grades were in short supply, and the small lots that became available commanded high prices. Some of the inferior dry steam smalls were plentiful and dull.

The Iron and Steel Trade.—Activities in the iron and steel trades of South Wales and Monmouthshire were still maintained at a high level, most works being engaged almost to full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The man-power position in the coal, steel and engineering trades has been discussed at a meeting in Sheffield attended by Sir William Beveridge on behalf of the Government. After the meeting an official statement was issued which we quote on page 278 of this issue. No material change has taken place in the steel, machinery, and engineering branches. Outputs have been fully maintained, and in some branches an increase is reported. Despite the heavy calls being made upon them, producers of raw and semi-finished steels are able to satisfy the needs of their customers. There is an exceptionally strong demand for both basic and acid steels, and steel-making alloys are in strong request. A highly satisfactory state of affairs exists in the heavy machinery and engineering branches. Business is more brisk in railway rolling stock and related equipment, and orders for wheels, axles, springs, tyres, and buffers are numerous; carriages and carriage parts are also in slightly greater demand. Shipyards are taking increased supplies of Sheffield-made steel, forgings and castings, turbine parts, auxiliary machinery, and deck furnishings. More business is passing in electrical plant, and grinding and crushing machinery is an active section. Firms specialising in the production of cement and concrete mixers have well-filled order books, many of the orders being in connection with A.R.P. work.

South Yorkshire Coal Trade.—Overseas business shows little change, and continues to be very restricted. The inland demand for coal has improved, and outputs at the pits show a tendency to increase. Steelworks and ironworks are taking increased tonnages. Steams are an active section, and locomotive coal is in better demand. The house coal market is also more active. Foundry and furnace cokes are steady, but coke for central-heating purposes is in increased demand.

CONTROL OF STONE, SLAG AND LIME.—The Minister of War Transport has made an Order, which is now in force, for the control of stone, slag and lime. The Order applies to producers, distributors or users of practically all igneous, metamorphic and sedimentary rocks, lime (except chalk lime) and slag (except basic slag). No person to whom the Order applies shall acquire, use or dispose of any of the materials specified except under the authority of a licence from the Minister. The Minister may attach to such a licence such conditions as he may deem necessary including the price at which the materials may be sold or bought, and the licence may be rescinded or varied at any time. Copies of the Order, entitled The Control of Stone, Slag and Lime, Order, 1941 (S.R. and O., 1941, No. 1302), may be obtained on application to H.M. Stationery Office, York House, Kingsway, London, W.C.2.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Existing conditions have necessitated a considerable reduction in the imports of iron and steel, but here little inconvenience is being caused as the local output is sufficient to enable the demand for material for work of National importance to be met. General commercial transactions, however, are difficult to arrange.

Cleveland Iron Trade.—No improvement in the meagre supply of Cleveland pig can be reported, but supplies of foundry iron from other producing areas are ample for current needs and enable some additions to be made to consumers' stocks. The tonnage passing through merchants' hands is increasing but the parcels coming under their control still fall short of the requirements of their regular customers. Consumers, however, experience no difficulty in purchasing adequate supplies from makers. The fixed prices of Cleveland pig are based on No. 3 quality at 128*s.* delivered in the Middlesbrough district.

Basic Iron.—The make of basic iron is adequate for the heavy demands of the producers' own steelworks but provides no tonnage for sale and the quotation of 120*s.* 6*d.* remains nominal.

Hematite.—The position in the hematite branch of trade is distinctly better than has been the case for some time and continues to improve. Although the shortage still causes some inconvenience ironmasters have adapted their works to the altered conditions and are producing qualities of iron that satisfy most of the needs of hematite consumers. Restriction of hematite distribution cannot yet be avoided and delivery allocations are made for essential purposes only. The recognised market values are at the level of No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England areas.

Foreign Ore.—Supplies of foreign ores, with the exception of descriptions required for hematite production, are substantial and satisfactory, cargoes are arriving regularly.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is very limited. Sellers have large holdings and consumers' requirements are heavy, but the former have extensive contract obligations and do not wish to increase their commitments while the latter consider that their requirements are well covered. The official quotations are ruled by good medium qualities at 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—Re-rollers are well provided with semi-finished iron and steel, the consumption of which is exceptionally heavy. Finished iron manufacturers have as much heavy work on hand as they can deal with, but would welcome orders for light material. Steel producers are fully employed, except in branches turning out structural commodities. Black and galvanised sheets are in strong demand, as also are ship, tank and boiler plates, and special alloy steels. Available parcels of railway requisites are promptly purchased.

Scrap.—Large contracts have been arranged for heavy cast iron, machinery metal, and heavy steel; and other grades of scrap are in strong demand.

CONTROL OF MAGNESIUM.—The Control of Magnesium (No. 1) Order, 1940 (S.R. & O. 1940, No. 1312, price 2*d.*), referred to a "fixed price." The effect of the Control of Magnesium (No. 2) Order, 1941 (S.R. & O. 1941, No. 1314, price 1*d.*), as from September 2, 1941, is to alter this wording, where appropriate, to "fixed or maximum price."

BOILERS FOR NEW CORVETTE.—We are informed by the Admiralty that they have been presented by Messrs. Babcock and Wilcox, Limited, with the complete boiler equipment for a new corvette. In his letter to the Admiralty when making the offer, the chairman of Messrs. Babcock and Wilcox (Lieut.-Col. Sir J. H. M. Greenly, K.C.M.G.) said that the gift was designed to express to the officers and men of the Royal Navy and the Mercantile Marine some measure of the gratitude that the members and employees of the company felt was owing to them "for hard duty unceasingly, efficiently and courageously done."

PREPARATIONS USED AS A PROTECTION AGAINST DERMATITIS.—Factories in which preparations are used for the protection of workers against dermatitis have been limited in the quantities they can obtain by the Limitation of Supplies (Miscellaneous) (No. 11) Order, 1941. If these firms are unable to obtain sufficient for their needs, and provided that one of H.M. Inspectors of Factories certifies that there is a risk of dermatitis in the nature of the factory work, the Board of Trade will issue a special licence to the supplier of the preparation. This will permit quantities to be obtained by the factory beyond the supplier's quota.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, October 4, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Informal Meeting. "Epidiascopes in General and the J.I.E. Epidiascope in Particular," by Mr. H. J. N. Riddle. *Midland Section.* Saturday, October 11, 3 p.m., The James Watt Memorial Institute, Birmingham. Annual General Meeting.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Saturday, October 4, 2.30 p.m., The Royal Victoria Station Hotel, Sheffield. Joint Meeting with THE SHEFFIELD METALLURGICAL ASSOCIATION and THE IRON AND STEEL INSTITUTE. (i) "Examination of a High-Sulphur Free-Cutting Steel Ingot," by Dr. E. Gregory and Mr. J. H. Whiteley. (ii) "The Thermal Relations Between Ingot and Mould," by Mr. T. F. Russell. (iii) "The Formation and Properties of Martensite on the Surface of Rope Wire," by Dr. E. M. Trent. (iv) "Note on the Resistance to Furnace Atmospheres of Heat-Resisting Steels," by Dr. A. G. Quarrell. (To be preceded by an informal luncheon at The Royal Victoria Station Hotel, Sheffield, at 1 p.m.)

NEWCOMEN SOCIETY.—Wednesday, October 8, 2.30 p.m., The Chartered Institute of Patent Agents, Staple Inn Buildings, W.C.1. (i) "The Development of the Practice of Evaporation," by Messrs. Noel Deerr and A. Brooks. (ii) "Automobiles in 1830," by Mr. Sydney Withington.

MANCHESTER METALLURGICAL SOCIETY.—Wednesday, October 8, 4.30 p.m., The Engineers' Club, Manchester. Joint Meeting with THE IRON AND STEEL INSTITUTE. (i) "The Polishing of Cast-Iron Micro-Specimens and the Metallography of Graphite Flakes," and (ii) "The Metallography of Inclusions in Cast Irons and Pig Irons," to be presented by Mr. H. Morrogh.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Students' Section:* Wednesday, October 8, 6.30 p.m., The James Watt Memorial Institute, Birmingham. The Students' Lecture: "Telecommunications of the Future," by Dr. W. G. Radley.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Wednesday, October 8, 7 p.m. The Victoria Hotel, Keighley. Lecture: "Some Problems of Mechanical Flight," by Mr. S. F. Benson.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, October 11, 2.30 p.m., The Engineers' Club, Manchester. Inaugural Address by the President, Mr. F. C. Anderson.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Active conditions continue in the Scottish steel trade and a notable feature is the steadily increasing demand for special high-grade steels. Ship and boiler plates are being turned out rapidly as consumers' demands are insistent. Structural engineers have a fair amount of work on hand and are using a considerable tonnage of steel. Priority orders are still accounting for almost all the steel production at present and it is almost impossible to secure material for other than essential purposes. Makers of black-steel sheets report that the demand for the thinner gauges is still strong and that they are well employed generally. The position regarding steel scrap is practically unchanged; an increased tonnage would be welcome. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Business in the West of Scotland malleable-iron trade shows little change. The tonnage of scrap coming forward is reported to be better, but heavier deliveries are wanted to ensure continuity of production. The re-rollers of steel bars are not particularly busy, and although they have a fair tonnage on order fresh contracts would be welcome and early delivery could be promised. Good stocks of semies are held. Prices are unchanged and are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There is no change to be reported in the Scottish pig-iron trade and all furnace are running at full capacity. The demand is still strong and the total production is rapidly consumed. Although hematite and basic iron are active, foundry grades are somewhat dull. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

DUAL-FUEL INTERNAL-COMBUSTION ENGINE.

MESSRS. THE NATIONAL GAS AND OIL ENGINE CO., LIMITED, ASHTON-UNDER-LYNE.

(*For Description, see page* 265).

Fig. 5.

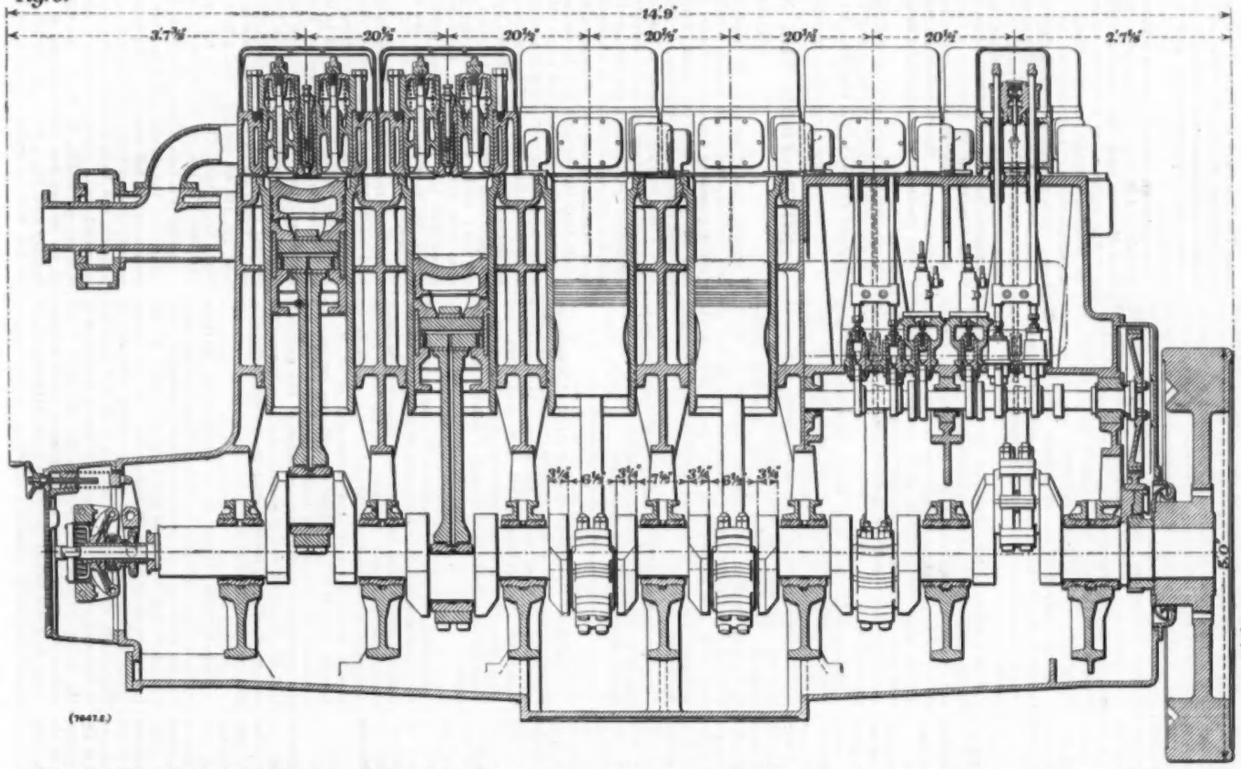
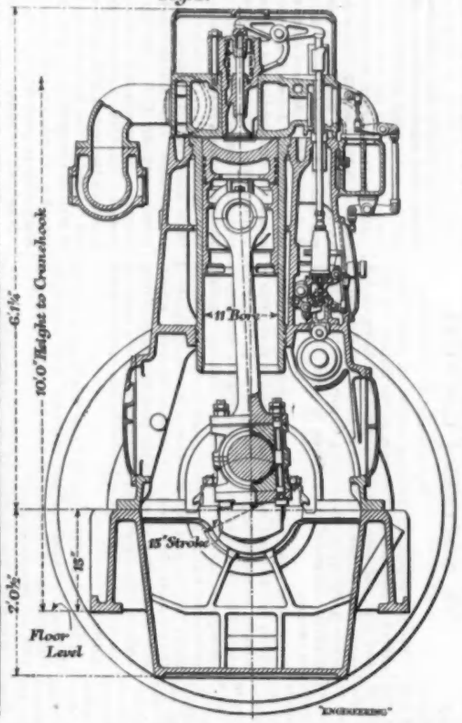


Fig. 6.



CHEMICAL INDUSTRIES EXHIBITION IN NEW YORK.

THE eighteenth Exposition of Chemical Industries, which will be opened at the Grand Central Palace, New York, on Monday, December 1, and will close on Saturday, December 6, will be on a larger scale than any of those held in the past twelve years. Applications are still being received from prospective exhibitors, although practically all the available space was allocated more than a month ago. As was to be expected, questions relating to material for the national defence programme will figure prominently in the exhibition but the advance made by the United States to make that country independent of imported raw materials will also be in evidence. Industries employing various chemical processes, which were started up during the war of 1914-18, are now taking a leading part in providing materials for the present defence programme, and it will be one of the incidental objects of the exhibition to point out the progress made during the past 20 to 25 years. Furthermore, some interesting forecasts of the post-war future will be made, and among other significant facts, the exhibition will emphasise that industries, which until recently had little or nothing to do with chemistry, are now consuming increasing quantities of chemical products and adopting chemical methods; that, in some spheres, artificial materials are rapidly replacing natural products; and that from laboratories and pilot plants, not merely new products, but entire new industries are emerging.

Among the exhibitors will be a number of chemical engineering firms specialising in the building and equipping of complete acid manufacturing plants, extraction plants, paint making and dye works machinery, paper making and printing ink machinery, and equipment for the manufacture of plastic material products. The chemical technology section of the exhibition will include exhibits of laboratory equipment and supplies, testing instruments and apparatus, text-books and periodicals. In the industrial chemicals section will be shown materials consumed in industrial processes, laboratory reagents, and compounds employed as raw materials in various industries. The chemical products and processing materials sections will contain exhibits of technical and commercial materials employed in industry or consumed by chemical manufacturers. In the manufacturing ingredients section will be shown raw, refined and semi-fabricated metals and minerals, as well as vegetable products, and synthetic materials, extracts and derivatives forming the basis of various productive operations. The exhibits in the manufacturing equipment section will consist of permanent and static plant components constituting essential parts of chemical installations, while prime movers, and specialised apparatus designed to perform particular mechanical operations, such as conveying materials and supplementing chemical processes, will be shown in the machinery and supplies section.

An important section will be that dealing with the control of processes. In this section will be exhibited instruments and apparatus for indicating, regulating and recording critical functions, such as temperature, pressure, moisture content, alkalinity, the proportions of mixtures, rates of feed, the levels of liquids, and so on. Another important section will be that devoted to exhibits relating to the construction of plant. These will deal with housing and with heating and ventilating, lighting, sound-proofing and similar plant essential to the operation of a modern factory and to the health and well-being of the employees. The last section will be interesting in that it will deal with containers for finished products, and with dispensing and packaging equipment. Methods of storing and conveying products and measuring and weighing, bottling, boxing, sealing and labelling apparatus will also be shown. Taken altogether, the exhibition will cover a very wide field and it is expected that the conferences which will be attended by the scientists, engineers and manufacturers visiting the exhibition will not only help to solve many new problems but will also bring to light new solutions to many of the old problems which are now confronting the industry.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, OCTOBER 3, 1941.

VOL. 152. No. 3951.

SCIENCE AND WORLD ORDER.

"WHEN the laws regulating human society are so formed as to come into collision with the nature of things, and in particular with the fundamental realities of human nature, they will end by producing an impossible situation which, unless the laws are altered, will issue in such catastrophes as war, pestilence and famine."* In making this statement, Miss Dorothy L. Sayers explains that the laws referred to are legislative enactments, or laws imposed by codes of custom ; the laws of nature, which are formulated expressions of observed scientific fact, of necessity cannot come into collision with the nature of things, and cannot be altered. History records more examples of the types of catastrophe instanced by Miss Sayers than can be counted, but a decrease in the incidence of pestilences and famines may at least be set down on the credit side of the balance sheet of human progress in modern times. Unfortunately, the war entry on the debit side is as heavy in the Twentieth Century as it was in the Middle Ages.

While scientific advance has greatly improved the material well-being of mankind, it has done nothing to control the ambitions and passions which, pent for a time, issue again and again, after uneasy pauses, in the cataclysm of war. The growing realisation of this unsatisfactory state of affairs is probably the seed from which the British Association conference on Science and World Order sprang. Sir Richard Gregory, the President of the Association, stated at the first meeting on Friday of last week that the committee concerned had been surprised by the overwhelming success of the conference. Something much more modest had been originally contemplated. The Division for the Social and International Relations of Science, under the auspices of which the conference was held, was formed at the Cambridge meeting of the British Association three years ago, and the mere formation of the Division was evidence of a feeling that in some way science should endeavour to exercise more control over human affairs. That such a feeling is widespread, even in circles having no connection with science, is made clear by the support afforded to the conference, which was held at the Royal Institution. It received messages from the King, the Prime Minister, General Smuts and Professor Einstein, and was attended by the Ambassadors of the United States, Russia and China, by Dr. Benes, Mr. H. G. Wells and an assembly of professors and politicians too numerous to mention individually.

Of the large number of communications presented at the conference, the majority were records of what has already been accomplished by science in ministering to the material advance of the human race ; in most cases they were accompanied by pleas that work already being done should be increased in scope. Sir John Orr, for instance, stated that in the decade preceding the outbreak of war, some governments, realising the importance of the new science of nutrition, took measures to improve the diet of the poorest, with striking results. There was a great decrease in deficiency diseases, a reduction in infant mortality and tuberculosis death rate, and increase in the stature and physique of school children. The diet of the majority of people was, however, still below a satisfactory standard and a general food policy which would bring a proper diet within the reach of all would form an important step towards a better world order. In a field with which this journal is more closely concerned, Sir Harold Hartley reviewed the heat and power requirements of the world, and made a plea for development and research which would bring the benefits of organised power supply to all countries. We reprint his address on page 277 of this issue. As one more example, Dr. Othmar Ziegler dealt with the possibility of developing transport systems in the south-eastern part of the Danube basin and the effect it might be expected to have on the standard of life in that thickly-populated area.

Communications of this type were a necessary and proper feature of the conference. They presented data showing what has already been done in applying scientific methods to social problems and suggested ways in which its benefits might be augmented. In many cases the results achieved have followed the application of some type of public control to problems previously left to private enterprise, as, for instance, in the case of the Tennessee Valley Authority, the operations of which were described in a paper presented by Professor Luther Gulick. It has become the fashion to describe large-scale activities of this kind by public bodies as "planning." The transfer of the administration of important services from private to public, or semi-public, control which they represent is quite familiar in this country. It is possible that the future may see considerable extension of the practice and in as far as the conference helps to educate the public and its political leaders to the necessity for close co-operation with scientific men in activities of this kind it will be of value. It may be hoped, however, that its proceedings will not create an impression that public ownership or control are necessary features in the utilisation of scientific progress for the benefit of mankind.

There are two reasons why the most spectacular results of "planning" are associated with public control : these are the facts that there is little or no restriction on capital expenditure and that frequently no return in the form of a dividend is looked for. Sir Harold Hartley stated that over half the world population lives in the less developed countries and that its first need is cheap transport. Applied science would find no difficulty in providing such transport, but might have considerable difficulty in making it a paying proposition. If public ownership allows the latter condition to be waived, on the basis that the improvement in social status of the communities concerned is a sufficient return, then clearly much development can be undertaken. This appears to be the general message of the conference. It had little to say of economic possibility and much of what might be done by utilising all that science has shown to be possible. To do this fully, international co-operation would be necessary. Dr. Desch said that there were indications that the world supply of copper, tin, gold and phosphates, at the present rate of production, could be continued

* *The Mind of the Maker*, Chap. I.

for less than a century, and pleaded for some form of international control. Clearly, this would include all countries.

This brings us back to the point from which we started. Of the three evils instanced by Miss Sayers—war, pestilence and famine—the service now being rendered by organised science may roughly be said to correspond to the control of the two latter. So far the scientific method has been applied to ensure that the legal enactments, under which many public services are operated, begin to have reasonable relation to natural laws. They correspond to "the nature of things" and bring benefits which the unscientific procedure of the past could never have attained. Full international co-operation, however, has not yet been reached and one of the hopes of which the conference was an expression was that the post-war era may show great extension of the area over which the benefits of applied science are spread.

The conference took for its title Science and World Order, which, in present circumstances, must be held to imply that in some way, science can offer assistance in the present world disorder, that it can do something towards the solution of Miss Sayers' first term. That war is due to the laws regulating human society coming into collision with the nature of things may be accepted as a general proposition, without an admission that the laws of nature, as they come within the ambit of the British Association, can in themselves control its incidence or extent. The science of a very distant future may explain the disordered ambition that plunges half the world into war; that of to-day can do no more than lend material aid to those on whom war has been forced. Science, in itself, is as ready to assist the aggressor as the defender, the only favour it shows being that in as far as the aggressor, in crazy vanity, cuts himself off from the scientific work of others, so will his apparatus of terror be the less effective. The result of this deprivation will be cumulative, and as the intellectual capital of the past is exhausted so will the science of the self-centred breaker of the peace fall farther behind.

Science, however, is not a system of ethics and it is not competent to put forward solutions for the problem of war. Its interests are not served by assuming that it can ensure that the next peace will be a lasting one. Dr. Benes stated that the conference was a manifestation of a definite and firm will not to permit in the future the misuse of technological progress for criminal and destructive purposes. This point of view appeared in the remarks of other speakers. Even the Charter of Scientific Principles which has been adopted by the Council of the British Association, and was presented at the termination of the conference, contains the statement that "To-day they (scientific workers) feel compelled to proclaim their special responsibility in the struggle against subjection which would lead to the betrayal of intellectual liberty."

The point of view represented by expressions of this kind is not of service to science. Scientific men have no special responsibility for world order and in so far as they attempt to assume it they are leaving the scientific sphere. There is no reason why they should not do this individually, but equally there is no reason why a musician or a painter should not. The special responsibility of science is to ensure that as far as possible its benefits should be extended to all forms of government, and the conference will have performed useful work if it has done something to educate politicians, and the general public, to the advantages that may follow practical application of the knowledge which science has made available. What appeared to us as the most practically useful way of looking at the problem presented was that put forward by Mr. Herbert Morrison. He pointed out that experience with the application of the scientific method in the social sphere was now sufficiently great to enable proposals to be made with the backing of scientific authority. He looked forward to a time when the programme of a political party would be scrutinised from the point of view of its ascertainable scientific validity, vague vote-catching programmes, having no relation to possibility, being automatically eliminated. In building up a public opinion which will bring this condition of affairs nearer, the scientist is well within his sphere.

THE CONTROL OF WAR PRODUCTION.

One of the few comments evoked in the House of Commons by Mr. Churchill's survey of the progress of the war, some leading points from which are summarised on the opposite page, was that the Prime Minister, "who in the past had been a most formidable critic," and other Ministers, were inclined themselves to resent criticism, although it might have been instigated only by a desire to help the war effort to the full. A somewhat similar impression has been given from time to time by the official attitude towards criticisms of the increasingly detailed control by Government departments of all branches of manufacturing industry. It is common knowledge that difficulties have arisen in the process of imposing, or attempting to impose, a unified control over the many thousands of manufacturing firms in this country, a large proportion of which, in the past, have felt little need to collaborate closely and, without actually denying the advantages of collaboration, are inclined to regard them as problematical so far as their own affairs are concerned. War-time production on a national scale, however, necessitates some over-riding control on a corresponding scale, and lack of experience in handling the colossal quantities involved is almost certain to result in some loss of efficiency by comparison with the relatively minor operations of ordinary commerce.

For this reason, while recognising that there are decided shortcomings in the practical application of Governmental control of virtually the whole productive industry of the country, we are inclined to doubt whether a much higher standard of efficiency would have been attained if the supply ministries had confined themselves merely to the purchasing of commodities, as suggested by Mr. E. C. Gordon England in his address, on September 24, to the Engineering Industries Association. War production in the engineering industries, he declared, has declined, whether it be measured per square foot of factory space, or in pounds weight of product per man-hour; and he maintained that the principal cause is "the lack of an adequate and comprehensive plan to use to the full all productive capacity and every available man-hour, both material and operative. . . . Production engineers and manufacturers know that the efficiency of our present facilities could be greatly increased and that the total capacity of this country is far from being fully employed."

To correct this failure to utilise the full resources of the country, he considers, "we need urgently a new conception of the relationship between the Government and industry that will enable an all-embracing design and plan for production to be brought into operation. . . The science of production is but little known in the production departments. . . Those who negotiate contracts with the supply ministries will know that almost the last thing discussed is efficiency of production. . . . Their worship of precedent, routine system and regulations is hopelessly out of tune with the principles of modern production. Some of the leading production engineers have come to the conclusion that the supply ministries should be primarily concerned with the function of buying, that the responsibility for production should be put on the manufacturer who should be given full authority and responsibility for carrying out this task. This would involve the substitution of modern business methods for Civil Service procedure, and that financial assistance for the expansion of businesses to carry out Government contracts should be judged by the capacity of the management to produce a given output rather than by conventional financial standards of credit-worthiness. Labour should be assured of full employment on essential production under sound management. There should be a consistent wages policy and no excessive management salaries or dividends. Coincident with these provisions, there must be no great rise in the cost of living. The incidence of taxation should be revised to avoid the anomaly and injustice of firms receiving widely varying rewards for identical services to the State."

We have quoted Mr. Gordon England at some length, because there is no doubt that the views which he has expressed are held by many others besides himself and his colleagues in the Engineering Industries Association. It is equally certain that there are many anomalies, wastages of effort, and even injustices incidental to the present method of controlling productive industry from Whitehall; labour is not always fully employed, and management is sometimes less than sound; the wages policy, if it exists, is not always consistent or even obvious; and the incidence of taxation causes justifiable anxiety in the minds of those whose vision extends beyond the immediate concerns of the moment. It is not quite clear, however, how the alterations in procedure advocated by Mr. Gordon England can be effectively introduced in the middle of a war; or what safeguards are to be provided that will ensure a positive improvement on the present results (which are not inconsiderable) while preventing other handicaps and hindrances to production, the creation of new anomalies and inequalities, and the imposition upon industry of a new Civil Service differing in little except the title from that which it suffers already.

It would seem that the new form of industrial administration envisaged by Mr. Gordon England is, in effect, no more than a vast scheme of "rationalisation"; and it is by no means certain, if past experience is any guide, that rationalisation is a medicine that can be safely taken undiluted. Individual firms may have worked more smoothly and efficiently before they were subjected to Government control, but that circumstance offers no positive assurance that they would continue to do so under war conditions, when only Government purchasing can ensure a supply of materials and tools in sufficient quantity, and only the Government can settle the many vexed questions of priority that arise inevitably when the needs of the fighting Services must somehow be reconciled. The manner in which these functions are carried out may, and frequently does, fall short of perfection; but the fact remains that no alternative organisation would be likely to improve greatly upon it, for the simple reason that no delegated authority could be quite so effective as the authority of the Government itself. The delegation could never be 100 per cent. complete, and border-line cases must continually arise in which the Government would be obliged to intervene.

We would be among the first to admit that the present system is not ideal; but, while sympathising with many of the criticisms voiced by Mr. Gordon England and others who have had reason to complain of the obstacles that hinder a higher rate of production, we still doubt whether his proposed limitation of departmental functions, to give a freer hand to the individual manufacturer, would effect the desired result in view of the scale of the operations involved in arming, feeding and directing an entire nation. Real "captains of industry" are never plentiful, and they cannot be improvised. Whether the productive efforts of British industry are to be controlled by the ministries or by industry itself, there must still be more posts for supermen than there are genuine supermen to fill them, and there must still be an excess of "paper work," compared with the standards of peace-time commerce. Therein lies the real weakness, and it is one that affects the totalitarian states no less than any other kind, as well as being a fundamental defect—though not the only one—in all forms of nationalisation. The Civil Service may be accused, and reasonably, of regulation-worship; but the essence of mass production, also, is a rigid adherence to rules and schedules, any departure from which is liable to disorganise the whole scheme, and defeat its objects. The substitution of one form of regimentation for another seems unlikely to raise the overall efficiency of production. A process of "derationalisation" might do so, but that hardly appears practicable in present circumstances. We consider that the mobilisation of industry in this war compares favourably with the achievements of the last. There is still much room for improvement, but this is more likely to be accomplished by keying up the existing organisation than by altering its fundamental structure.

NOTES.

THE PROGRESS OF THE WAR.

THE Prime Minister's speech in the House of Commons on September 30, while it contained little to encourage those who foresee a German collapse in the coming winter, did offer substantial ground for satisfaction in certain other respects, especially in his reference to the shipping position. The losses from enemy action of British, Allied and Neutral shipping during July, August and September, he stated, were only one-third of the losses during the preceding quarter—neglecting, of course, any that might have occurred on the day when he spoke, particulars of which could not be included for obvious reasons. He mentioned no figures, but it may be noted that the losses for the quarter which ended on June 30 were 318 ships, totalling rather more than 1,400,000 tons. During the September quarter, Mr. Churchill continued, "the slaughter of enemy shipping, German and Italian, has been increasing by leaps and bounds" and has totalled about one and a half times the figure for the previous quarter. Very few important ships carrying munitions for the British and Allied Forces have been lost on the way, and the reserves of food stand higher than they did at the outbreak of the war and "far higher" than they did a year or 18 months ago. He added a warning, however, that it must be expected that the U-boat warfare, supported by "scores of Focke-Wulfs," will be intensified; and that it can be overcome only by a corresponding intensification of counter-measures, supplemented by the assistance that is arriving in increasing degree from "other quarters." Turning to the situation in Russia, Mr. Churchill said that the British and United States missions in Moscow had gone there with a full and clear knowledge of what they were able to give to Russia month by month. To enable the Russian armies to remain in the field as a first-class war-making power, the most extreme efforts would have to be made by the British people, and enormous new installations or conversions from existing plants would have to be set up in the United States. It was not only tanks that would have to be sent to Russia, but aircraft, aluminium, rubber, copper, oil, and many other minerals vital to modern war. Large quantities had already gone. It might be that transportation, rather than willingness or ability to give, would prove to be the limiting factor. The Prime Minister then referred to the equipment and training of the British Army, and particularly to the new demands for skilled manpower, required for the mechanised branches of the Forces. It was inevitable, he said, that the British Army should be relatively small, by comparison with that of the enemy, and it was all the more necessary, therefore, that it should be highly mechanised and armoured. For this purpose, there must be a steady flow into it of skilled tradesmen and technicians, so that the weapons provided could be used effectively. There was no question of increasing the numbers of the Army, but it was indispensable that wastage should be made good, and the batteries and tank regiments should be kept at their proper strength. Above all, the existing formations must not be "pulled to pieces and gutted" by taking out trained men who were "an essential part of the living entities on which, one of these fine or foggy mornings, the whole existence of the British nation may depend." The enemy's only shortage, so far, was in the air, and the coming of winter gave no assurance that the danger of invasion would be entirely lifted from these islands.

THE CITY AND GUILDS INSTITUTE.

The annual report of the Council of the City and Guilds of London Institute for the year 1940 (the 61st since the incorporation of the Institute), although much briefer than has been customary, sufficiently demonstrates that the Institute is achieving considerable success in maintaining its usual educational services, except in those departments which are especially exposed to Governmental demands for man-power. These demands are least felt, probably, in the Department of Technology, but even here the influence of war conditions is very evident in the reduced number of examination candidates in Great Britain and Northern Ireland, which was only 50·4 per cent. of the number in 1939. The actual figures for the examinations in technological subjects in 1940 were 15,163 in Great Britain and Ireland and 4,107 overseas, a total of 19,270; which compares with 38,189 in the previous year, of whom 34,173 were in Great Britain and Ireland and 4,016 from overseas. Of the 4,107 overseas candidates examined in 1940, 2,697 sat at centres in India and 359 in Malaya; while those who sat at centres in New Zealand, the British West Indies, and in South Africa and Rhodesia, numbered 286, 200 and 92, respectively. In 1915, the report observes, the total number of candidates examined at centres overseas was only 634. The recognised standard of the examinations was maintained, but a wider choice of questions was given, to meet the difficulties of war-time instruction. Special arrangements were made for the assessment of practical tests in certain subjects. The Council comment on the quality of the scripts received, the percentage of failures in Great Britain and Ireland having been reduced from 35·4 per cent. to 30·2 per cent., and overseas, from 55·1 per cent. to 47·6 per cent. The income and expenditure account of the Institute shows that there was a reduction in the total income from 35,575*l.* in 1939 to 26,612*l.* in 1940, the principal decreases being in subscriptions and donations (from 16,512*l.* to 15,390*l.*) and in the receipts of the Department of Technology (from 15,821*l.* to 8,161*l.*); but considerable reductions were effected in expenditure, which declined from 34,461*l.* in 1939 to 27,486*l.* in 1940. The net result of these reductions, in conjunction with other small variations, was a deficit of 874*l.* on the year, as compared with a surplus of 1,114*l.* in the previous year. It is noted that contributions to the Institute, since its foundation in 1878, from the Corporation of the City of London and from the City Companies now amount to over 1,391,000*l.* The Council record with regret the deaths during the year of Dr. W. E. Sumpner, M.I.E.E., F.C.G.I., the first Clothworkers' Scholar (1885-7); Professor S. M. Dixon, O.B.E., M.Inst.C.E., the first professor of civil engineering and surveying and Dean of the College in 1931-3; Sir Arnold Wilson, K.C.I.E., a member of the Delegacy since 1932, who was posted as missing after the Dunkirk evacuation, in which he was engaged as an air gunner; and of Mr. T. Hodgson, B.A., B.Sc., formerly lecturer in the Department of Mechanics and Mathematics. The report also records that the Council have conferred the distinction of F.C.G.I. on Mr. H. C. Armstrong, M.Inst.C.E.; Dr. C. H. Desch, F.R.S.; Dr. A. P. M. Fleming, C.B.E., M.I.E.E.; and Dr. S. L. Smith, M.Inst.C.E., M.I.Mech.E.

ELECTRICITY SUPPLY IN SYDNEY.

The problem of the organisation of electricity supply over extensive areas has been dealt with in widely different ways in various parts of the world. Some of the methods adopted in the British Empire were described by Mr. J. R. Beard in his recent address to the London Students' Section of the Institution of Electrical Engineers, of which we gave a summary on page 247 of our issue of September 26. A further example of administrative possibilities for this important service is furnished by the arrangement adopted in Sydney, New South Wales. From 1904 to 1935, the supply of electricity in the City of Sydney and a number of suburbs was carried out by the Municipal Council of Sydney, but in 1936 the ownership and control of the electricity department passed to the Sydney County Council. This body, which consists of two members elected by the Municipal Council, two by the councils of 25 municipalities south of Sydney Harbour, and one by the councils of 7 municipalities north of the Harbour, supplies electricity to an area of 897 sq. miles, with a population of 1,075,060. Distribution is carried out by the Council in the City and 32 suburbs and it furnishes bulk supplies to the rest of the area, distribution being in the hands of 14 municipalities and shires and one company. The report of the Council for the year 1940, which has just become available in this country, records general and satisfactory progress. There has been some difficulty in obtaining supplies from overseas and at the end of the year 209 of the employees of the Council were absent on active service, but, nevertheless, it has been possible to meet all demands for power for munition works and to keep pace with the growth in general demand. In the year 1940, 804,370,100 kWh were generated at the Pyrmont and Bunnerong power stations, the figure for 1939 being 741,181,800 kWh. The annual load factors for the two years were 45·3 per cent. and 50·6 per cent. Only a very small proportion of the load was carried by Pyrmont, an old station which it is intended to reconstruct entirely by laying down a modern 200,000-kW plant on the same site. The first unit will be required for service in 1946. The load transferred from Pyrmont is being taken over by Bunnerong, Section B, at which the kilowatt-hours generated increased from 13,103,500 in 1939 to 200,583,600 in 1940. Section B contains two Parsons' 50,000-kW sets, but only the first had been put into commission by the end of the year. Section A is equipped with seven 25,000 kW Metropolitan-Vickers sets. The thermal efficiency of Bunnerong A, based on the gross calorific value of the coal, was 20·09, the figure for Bunnerong B being 24·66. The average price received per kilowatt-hour sold was 1·185*d.*, the figure for 1939 being 1·215*d.* This reduction in selling price was made in spite of a rise in fuel costs from 0·170*d.* per kilowatt-hour sold, to 0·177*d.* The total cost per unit sold was identical in the two years, at 1·195*d.*, the fuel cost rise being balanced by a reduction in repair and maintenance charges. The Council does not supply any current for traction purposes, but to facilitate economic operation and load balancing, its system is connected to the White Bay Power Station of the New South Wales Railways. An interchange of supplies takes place which are adjusted to balance in each quarter. The maximum demand made by the railways was 21,400 kW, and the corresponding demand made by the Council on the White Bay station, 20,800 kW.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

For the 58th session of the North-East Coast Institution of Engineers and Shipbuilders, which commences with the annual general meeting, to be held on October 17, a full programme of papers has been arranged for 1941, and arrangements are well advanced for the 1942 meetings of the session also. At the annual general meeting, a short address will be delivered by Mr. W. A. Woodeson, who has consented to remain in office as President for a second year. On October 31, the Andrew Laing Memorial Lecture will be delivered by Sir Westcott Abell, K.B.E., who recently retired from the Chair of Naval Architecture at King's College, Durham. The dates provisionally arranged for subsequent meetings are as follows: The paper to be read at the ordinary meeting on November 14 is that of Dr. M. R. Youssef, the subject being "Wind-Tunnel Experiments on Model Reaction Turbine Blades." If, as is possible, Dr. Youssef is obliged to return to Cairo before the date fixed for the meeting, the paper will be presented by Dr. T. W. F. Brown (member of Council). On November 28, Dr. F. H. Todd and Mr. J. Weedon, of the William Froude Laboratory, will read a paper on "Further Experiments with Models of Cargo-Carrying Type Coasters." There will be only one meeting in December, on the 12th, when Dr. A. Caress will read a paper on "Plastics and Engineering." On January 9, 1942, Principal F. H. Reid, B.Sc., Wh.Ex., will present a paper on "Training of Craftsmen for the Engineering Industry." Other papers, for which definite dates have not yet been allotted, include one by Dr. W. H. Hatfield, F.R.S., the title of which is not yet available; "The Testing and Inspection of Welds," by Mr. H. N. Pemberton; "Ballasting," by Mr. H. Bocler; and "Roughened Hull Surface," by Mr. R. W. L. Gawn, R.C.N.C.

HIRE OF BUILDING AND ENGINEERING PLANT.—The Minister of Works and Buildings has issued the Control of Rates of Hire of Plant Order, 1941 (S.R. & O. 1941, No. 1277, price 2d.), fixing maximum rates of hire for certain types of plant employed in the building and civil engineering industries and giving powers for the inspection of books, accounts or other documents in connection therewith.

LETTERS TO THE EDITOR.

THE BRITISH MERCANTILE MARINE.

To the Editor of Engineering.

Sir,—In Engineering of September 19, 1941, there appeared an article "The British Mercantile Marine." In that article the writer refers to what I said on September 10, when speaking in the House of Lords in support of Lord Marchwood's motion, in the following terms: "The Earl of Cork certainly observed that 'the line of demarcation between industrial interests and national interests would have to be clearly drawn' and implied that it would be one of the functions of the proposed Royal Commission to indicate where and how it should be drawn; but such a suggestion does little to clarify the issue." The article goes on to say, "The plain fact is that, where the Mercantile Marine is concerned, legitimate industrial interests and national interests are one and the same; there can be no question of drawing lines between them. A flourishing merchant fleet is the finest asset that this nation can have, but it can only flourish if it is in a position to compete on reasonably level terms in the world's carrying trades." Evidently my meaning was not made clear. May I be allowed the space to try and make it so?

During the years preceding the present war, it was made quite evident that the Mercantile Marine, in view of the subsidies granted to their shipping by foreign governments, was not in a position to compete on "reasonably level terms in the world's carrying trades" unless it also was helped by the State. During the two years this war has lasted, it has been made only too clear that many of the ships of the Merchant Navy were not suitable for the war needs of the country, many being too slow, lacking strengthening to receive an armament, etc.

Obviously, if the ships had been built to suit possible war needs, *i.e.*, of a higher speed, strengthened, with space allocated for magazines, etc., they would have been still less able to compete in the world's carrying trade. To illustrate my meaning: A ship that can maintain a sea speed of 9 knots might be a sound economic proposition on a certain route or in a certain trade, but will cease to be so were a sea speed of 12 knots to be insisted upon, necessitating, as it would, increased space for engines, boilers, fuel, etc., thereby either reducing cargo space or necessitating a larger vessel.

The industrial interests then came into conflict with the national requirements, obviously the latter being best served by the faster ship. A 9-knot vessel is a danger in war, delaying other ships and other cargoes when in convoy, and thereby not only slowing down supply but exposing her consorts and her escort to the risks of war at sea for a longer period than, at a greater speed, would be necessary. The difference between what is justified by sound business considerations, and the extra cost of the vessel altered to suit the national requirements should, I suggest, be borne by the State. It would be unfair to saddle the owners with this expense, and to do so would strike a blow at industry generally.

Again, as regards the personnel: So far as its business is concerned the industry is well served under normal conditions by officers and men trained upon existing lines, but in abnormal times the nation has the right to demand that the same officers and men should be competent to defend their ships and the cargoes they carry, and to render them efficient to do this would necessitate training in several directions not essential to their normal business needs. This training, in my view, should also be a charge on the State, as being an extra necessitated by national requirements.

What proportion of the whole expense should be borne by the industry, and what by the national Exchequer, and upon what system it should be paid, are two of the many points which could only be decided after an exhaustive inquiry into the shipping industry as a whole. This inquiry, if the findings are to command the support of the nation, must be carried out by an independent and impartial body of men of standing in the nation's affairs, who could be trusted to see that the nation, the industry, and the personnel of the Merchant Marine alike, all receive just treatment. To effect this the powers of a Royal Commission seem called for.

I am, Sir, Yours, etc.

Cork and Orrery.

46, Ennismore-gardens,
London, S.W.7.
September 27, 1941.

THE CONTROL OF POWER IN LARGE INTER-CONNECTED ELECTRIC SUPPLY SYSTEMS.

To the Editor of Engineering.

Sir,—To those who have spent much time in explaining the technical basis of the British Standard Specification for Oil Circuit Breakers (B.S.S. 116/1937), it will be rather discouraging to read Dr. Wall's remarks on pages 222 and 223 of your issue of September 19. The power interrupted by one pole of a circuit breaker is not defined as "the product of the r.m.s. value of the interrupted current and the r.m.s. value of the recovery voltage"; in fact, the conception of interrupting "power" is fallacious and finds no place in the specification. The breaking capacity of a circuit breaker is defined as the r.m.s. value of the alternating current component of the current broken at a stated recovery voltage, and for practical convenience may be given as the product of that current and the rated service voltage.

The object of the calculation on page 223 is not quite clear and its effect may be to cause confusion. The result, namely that the breaking capacity of a given three-phase breaker in MVA (not mVA, by the way) is three times the product of the r.m.s. current broken (in kA) and the system phase to neutral voltage (in kV), follows immediately from the correct definition of breaking capacity. No such calculation as Dr. Wall gives is ever made when computing the results of short-circuit tests and although the values of the currents and voltages are correct, it corresponds to no physical reality. The interpretation of the data of the numerical example a little lower on the page, does not correspond to B.S.S. 116/1937. The breaking capacity rating of the breaker should be $16{\cdot}8 \times \sqrt{3} \times 6 = 170$ MVA. The practice of calculating the MVA capacity of a breaker as the product of a certain breaking current and recovery voltage and then selling the breaker as though it were suitable for a higher breaking current at a lower recovery voltage is one that has been followed for years by less scrupulous manufacturers, particularly on the Continent. It is unfortunate that Dr. Wall should have used a rather bad case of this malpractice as an example to illustrate his remarks.

Yours faithfully,

C. J. O. Garrard.

Four Oaks,
Birmingham.
September 24, 1941.

MACHINE TOOL CAPACITY.

To the Editor of Engineering.

Sir,—Although some of your readers may already have been in contact with the Machine Tool Capacity Clearing Centres of the Production Executive Regional Boards, there may be others who have not learned of the help these Clearing Centres can be to works managers, production managers and other executives when up against the problem of finding spare capacity or of finding work for temporarily idle machines.

In the London and South Eastern Region (London, Kent, Sussex and Surrey) we have ten Clearing Centres. They are in effect Capacity Exchanges, designed to do for manufacturing capacity what the Employment Exchanges do for labour. Each is in charge of a technical officer of the Board. The Clearing Centres have a comprehensive register of the firms in their district and of their machine-tool facilities. They keep in touch with firms who have spare capacity for which they want work, even when the spare capacity may be available for short periods only. Spare capacity fluctuates from day to day, but the aim is to waste none of it that can be used to the national advantage. All this information is kept at the Clearing Centres in a simple but systematic way, so that when a firm asks for assistance it can be put into touch with what it wants with a minimum of formality and delay. Needless to say, the business of fixing prices, deliveries, etc., is left to the two parties who have been introduced.

Altogether, the Clearing Centres of the London and South Eastern Regional Board effected over 2,000 successful introductions between January and July. In about three-quarters of these the value of the job was given, and they totalled over a million pounds. I must stress that this is entirely out of ratio with the unassessed value: a million does not sound a lot when the nation is spending many times that amount every day. The only true monetary value that could be put on these introductions is the total value of the contracts that would have been held up without them.

The Clearing Centres aim at fostering a friendly spirit among the firms in their districts. The technical officer in charge of the Clearing Centre gets on close relations with the factory managers in his district and the danger of factory managers feeling they are going to run into a fog-bound maze of red-tape bestrewn blind alleys is eliminated. There is then a much better chance of factory managers getting together among themselves and seriously co-operating with each other—which is just the object of the whole Clearing Centre scheme; and there is far less chance of any capacity being overlooked.

May I urge all concerned to get into touch with their local Clearing Centre at once? There is nothing to be lost, since the service is free. Like all Exchanges, the more people use them, the more efficiently they run. The greater number of new users, the better service everyone gets, with a widening of the scope of possible benefit to all. The addresses of the Centres in the London Region are appended. The scheme is being rapidly extended to other Regions and provincial inquirers can obtain details from their respective Regional Boards.

Yours faithfully,

Simon Marks.
Deputy-Chairman,
London and South-Eastern Regional Board.
Brettenham House,
Lancaster-place,
London, W.C.2.
September 25, 1941.

[From inquiries that we have received from time to time, we believe that the information contained in Mr. Marks' letter will be welcomed by many owners of machine tools who may have plant that is temporarily idle, as well as by firms who have urgent sub-contracts to place. The list of Clearing Centres in the London and South Eastern Region, with their telephone numbers, is as follows: We understand that particulars will be available shortly of those which are being established in other parts of the country. Acton: 60a, High-street, W.3 (telephone Acorn 5071). Croydon: Equitable House, George-street (Croydon 5189). Edmonton: 198, Fore-street (Tottenham 5481). Eltham: 20, Court-road, S.E.9 (Eltham 5588). Harrow: 15, College-road (Harrow 2602). Ilford: Rooms 15 and 23, Cranbrook House, Cranbrook-road (Ilford 0038). Westminster: Room 429, Romney-House, Marsham-street, S.W.1 (Franklin 2211, extensions 2680 and 2673). Guildford: 32, High-street. Rochester: Moat House, The Esplanade (Strood 7276).—Ed., E.]

The Late Mr. J. P. Anderson.—We announce with regret the death, on September 6, of Mr. James P. Anderson, manager of the Land Installation Department of the London office of Messrs. G. and J. Weir, Limited, Cathcart, Glasgow, S.4., since 1929. Mr. Anderson served his apprenticeship with Messrs. Alley and McLellan, Limited, Glasgow, and joined the technical staff of Messrs. G. and J. Weir, at their head office, in May, 1913. He served in the Army during the war of 1914-18 and was demobilised with the rank of captain. Resuming his duties with Messrs. Weir, he spent some years in the drawing office and estimating departments before his transfer to the London office in 1929. He had been associated in London with the installation of Weir auxiliaries in some of the largest power stations in the country.

OBITUARY.

MR. GEORGE BALFOUR, M.P.

IT is with regret that we record the death, on September 26, in a nursing home in London, of Mr. George Balfour, Member of Parliament for Hampstead since 1918, and founder and head of the firm of Messrs. Balfour, Beatty and Company, Limited, electrical engineers and contractors, London. Mr. Balfour was born at Portsmouth on November 30, 1872, and received his education at Mile End Academy, in his native town. In 1888 he commenced a five years' apprenticeship with Messrs. Urquhart, Lindsay and Company, of Dundee, meanwhile continuing his technical education at the Technical Institute and University College in that city. In 1893 he superintended the erection of a complete extension to his firm's works, including the building operations and the engineering equipment of all the departments from the iron foundry to the finishing shops. After gaining some electrical experience with Messrs. James Maxwell and Sons, Dundee, and serving for some months in the works of Messrs. Lowden Brothers and Company, electrical engineers and contractors, Dundee, he became assistant engineer to the Edinburgh Corporation in April, 1895. In November of the same year, however, he returned to Lowden Brothers as manager of their works, and, in 1899, was taken into partnership. He was responsible for the construction of electric tramway and light railway systems in various parts of England and Scotland, including the conversion to the overhead system of the Blackpool Electric Tramways and the lay-out and equipment of tramways at Southend, Shipley, Ayr and Dundee. He also superintended the construction of a number of municipal electric lighting plants.

The firm of Messrs. Balfour, Beatty and Company, Limited, was established in 1909, and during the past 30 years has been engaged in carrying out many important works. Prominent among these was the great Kut Barrage in Iraq, which was commenced in 1923, its object being to regulate the waters of the River Tigris for irrigation purposes. In addition to his work as chairman of Balfour, Beatty and Company, and his Parliamentary interests, Mr. Balfour was chairman of the Power Securities Corporation, Limited; the London Power Company, Limited; the Metropolitan Electric Supply Company, Limited; the Midland Counties Electric Supply Company, Limited; the Perak River Hydro-Electric Power Company, Limited; the Lancashire Electric Light and Power Company, Limited; and the Scottish Power Company, Limited. He was also a director of several other companies, and, in January last, was appointed by Lord Reith, Minister of Works and Buildings, to be chairman of the Committee on Cement Production. Mr. Balfour was elected an associate member of the Institution of Mechanical Engineers in 1902, and a member in 1929. He became a member of the Institution of Electrical Engineers in 1904.

MR. MAURICE DEACON.

WE have to record, also, the death of Mr. Maurice Deacon, which occurred at his home at Whatstandwell, near Matlock, Derbyshire, on September 25. Mr. Deacon, who was consulting engineer to, and a director of, a number of mining and other companies, was born on November 11, 1850, and served his pupilage in 1866 and 1867 with Messrs. Giles and Brookhouse, Derby. Afterwards he was engaged in making geological plans for the Coal Commission and in surveying coal and iron-ore deposits in South Wales. In 1871, he was appointed resident engineer and manager of the Plasycoed Colliery, South Wales, and mineral and land surveyor of the Garndiffaith Collieries and Ironstone Mines. In 1874, Mr. Deacon became consulting engineer to and manager of the Bath Colliery Company, where he was responsible for the sinking of a large shaft and the design of colliery plant. Two years later he designed and superintended the construction of a large mining plant, including railway sidings and tunnelling, at Bettisfield Colliery, North Wales. In 1878, he opened a practice as a civil and mining engineer at Pontypool, and was consulted by two Local Boards in regard to the design and lay-out of sewerage and road works and the building of railway bridges. Later, he was appointed engineer and general manager to the Manners Colliery Company, Ilkeston, and consulting engineer to the West Hallam Coal and Iron Company, Limited. He also served for some years as general manager to the Blackwell Colliery Company.

Subsequently, Mr. Deacon was appointed chairman and managing director of Dinnington Main Coal Company, Limited; chairman of General Timber Supplies, Limited, Blaina Colliery Company, Limited, and Waterloo Tin-Plate Company, Limited; and a director of The Sheepbridge Coal and Iron Company, Limited, Rossington Main Colliery Company, Limited, and other colliery companies. At the time of his death he was a director of the Tinsley Park Colliery Company, Limited; Messrs. Partridge, Jones and John Paton, Limited; British Tar Products Company, Limited; Messrs. Southwood, Jones and Company, Limited; the Pluckley Brick and Tile Company, Limited; and Abertillery Works, Limited. He was elected an associate member of the Institution of Civil Engineers in 1886, was made a member in 1892, and later served as a member of Council. He was also for many years a member of the Institution of Electrical Engineers and a Fellow of the Geological Society. He served as President of the Institution of Mining Engineers in 1906-07.

MR. H. S. BALL.

MR. HARRY STANDISH BALL, O.B.E., M.Sc., Principal of the School of Metalliferous Mining, Camborne, Cornwall, died, after a prolonged illness, at High Inval, Haslemere, Surrey, on September 26. The eldest son of the late Mr. T. J. Ball, J.P., of Johannesburg, South Africa, he was born on September 9, 1888, and was educated at St. John's College in that city. In 1906 he entered the South African School of Mines, Johannesburg, which now forms part of the Witwatersrand University, and in 1909 was awarded the Transvaal Chamber of Mines Research Fellowship and Gold Medal. After spending the years 1910 and 1911 at McGill University, Montreal, where he gained the M.Sc. degree, he returned to South Africa. There, as a certificated mine surveyor and mine manager of the Union of South Africa, he served in the capacity of mining and metallurgical engineer on the staff of Messrs. Rand Mines, Limited, from 1911 until 1915. In 1912 he was awarded the Arthur Claudet and William Frecheville Prizes of the Institution of Mining and Metallurgy. In 1915 Mr. Ball joined the Royal Engineers and served with the B.E.F. in France until 1919. He was Commandant of the First Army Mine School and was later attached to General Headquarters as assistant inspector of mines. He was three times mentioned in dispatches, awarded the O.B.E. (Military Division) and was demobilised with the rank of Major. In 1919 he was appointed engineer and manager to the François Cementation Company, Limited, but relinquished this position in 1921 to become assistant manager, and later acting general manager, of the Apex (Trinidad) Oilfields, Limited, Fyzabad, Trinidad. Subsequently Mr. Ball returned to this country to take up the appointment of Principal of the School of Mines at Camborne. He was elected an associate of the Institution of Mining and Metallurgy in 1915 and a member in 1922. He was a Fellow of the Institute of Petroleum, having joined the Institution of Petroleum Technologists as an associate member in 1923, and was also a Fellow of the Geological Society.

COMMERCIAL JOURNEYS ABROAD.—United Kingdom firms who desire to apply to the Department of Overseas Trade for recommendations in support of applications for exit permits for commercial journeys abroad, should, in future, communicate with the Department of Overseas Trade (Exit Permit Section), Neville House, Page-street, London, S.W.1. (Telephone WHItehall 9040). This address should be given in full, both on the envelope and at the head of the letter.

AIR CONDITIONING OF INDIAN RAILWAY COACHES.

(*Concluded from page 225.*)

MAKING a number of reasonable assumptions, Mr. Saksena next proceeds to estimate the power absorbed by the refrigerator load. The machine is supposed to be a mechanical compressor driven by an electric motor, to which current is supplied by a generator driven by Vee-belts from one of the coach axles. The drive includes a gearbox and universal coupling shafts, and its overall efficiency is estimated to be from 55 per cent. to 60 per cent. As regards the refrigerating machine, the cycle efficiency, volumetric efficiency and mechanical efficiency are each estimated at 80 per cent., leading to an actual performance coefficient of 50 per cent. of the ideal. The ideal performance coefficient is based on the reversed Carnot Cycle in which heat is taken in at 500 deg. F. abs. and rejected at an average summer temperature of 582 deg. F. abs. These values allow a temperature differential of 20 deg. F. between the condenser and the atmosphere and between the evaporator and the dew point of the ventilating-air supply passing over it. Thus, the practical coefficient of performance is given by

$$\frac{0{\cdot}5 \times 500}{582 - 500} = 3$$

Hence the theoretical horse-power required per ton of refrigeration by such a machine amounts to 1·6 h.p. If the overall-efficiency of the drive be taken as 58 per cent., the axle horse-power absorbed by the summer demand of 4 tons of refrigeration per coach comes to $\frac{1{\cdot}6 \times 4}{0{\cdot}58} = 11$ horse-power, to which must be added 0·5 h.p. for the condenser fan and 1 h.p. for the air-circulating fans, making 12·5 h.p. per coach.

The comparison, in some detail, between the costs of air conditioning a coach by the electro-mechanical compression system previously considered, or by the alternative of an ice-activated system, forms an instructive appendix to Mr. Saksena's paper. Dealing first with electro-mechanical refrigeration, he takes the first cost of the equipment to meet both a maximum load of 4 tons of refrigeration and a heating load of about 4·6 kW, combined with train lighting equipment, and inclusive of servicing for a guarantee period of 1 year, to be 1,950*l*. Since the train-lighting equipment of an upper-class coach already costs 450*l*., and since the one year's servicing is worth 40*l*., the net capital cost properly attributable to air conditioning is 1,460*l*. On this amount, depreciation at 12·5 per cent. and interest at 4·5 per cent. come to 250*l*. annually. Depreciation at 4 per cent. plus interest at 4·5 per cent. is also allowed on the cost (450*l*.) of alterations, additional wiring, fitting, erecting and insulating the equipment, adding 38*l*. to the annual charge. Further interest and depreciation are chargeable against one standby coach for every four coaches in service, and against the first cost of spare parts and other supplies which must be kept in stock. These charges account for about 75*l*. annually. The total of fixed charges per coach in service thus amounts to 363*l*. Annual maintenance costs, including battery upkeep, are assumed to be 6 per cent. to 7 per cent. of the cost of the plant and thus amount to 112*l*.

In estimating operating costs, Mr. Saksena takes account not only of the power required to work the air-conditioning system during the cooling and heating seasons, but also that of hauling the increased weight of coach represented by the excess weight of the new equipment over and above that of the simple train-lighting equipment normally fitted. The weights in question are 7·25 tons and 2·75 tons, giving an additional weight of 4·5 tons due to air conditioning. A load factor of 57 per cent. on the power (11·5 h.p.) absorbed by the refrigerator and its condenser fan brings this figure down to the equivalent of 6·5 h.p. required for refrigeration on a 24 hours' continuous operation basis. When 1 h.p. is added for the air-circulating fans in the coach, and 0·25 h.p. for frictional loss of power between the locomotive drawbar and the

coach axle, the requisite drawbar h.p. is 7·75 for refrigeration. A further 3 h.p. is absorbed in hauling the additional 4·5 tons weight of coach at an average speed of 40 miles an hour, train resistance being taken as 6·5 lb. per ton. Altogether, therefore, summer air-conditioning requires 10·75 draw-bar horse-power continuously when the coach is in service. At a consumption rate of 3·5 lb. of coal per drawbar horse-power per hour, and on the assumption that the coach is in service for 75 per cent. of the time it is on line, the power for air-conditioning demands 9 tons of coal, costing rather more than 8*l.*, per month.

The corresponding calculation for the 4·6-kW heating demand in winter is based on the assumptions of 95 per cent. efficiency for the heater and generator, 58 per cent. efficiency (as before) for the drive, and a load factor of 20 per cent. In other words, the maximum power absorption for heating is 10 h.p., but since this maximum is required for only 20 per cent. of the time the coach is in service, the power demand on a 24-hourly basis is only 2 h.p. Power requirements for air circulation and haulage are the same as during the summer, and the average cost of locomotive coal to be debited against heating amounts to nearly 5*l.* a month. Two features of these operating figures are specially noteworthy. First, the plant is well balanced, so that it requires almost the same horse-power when working at its full-load heating capacity as at its full-load refrigerating capacity, the values being 14·25 h.p. and 15·75 h.p., respectively. Unused plant capacity during part of a complete year is therefore largely avoided. This points to the second feature of importance, namely, if the external temperatures are such that neither heating nor cooling is needed, *i.e.*, the load factor for a period is zero, the operating costs still amount to 3*l.* per month per coach merely for hauling the extra weight of the plant and circulating fresh unconditioned air.

Mr. Saksena's analysis of the economics of an equivalent ice-activated cooling plant, combined with electric heating for use during cold weather, follows much the same general lines as that exemplified for the electro-mechanical air-conditioning system and only a few points of detail need be mentioned. The first cost is somewhat lower, at 1,500*l.*, and the fixed annual charges and maintenance are correspondingly reduced to 270*l.* and 97*l.*, respectively. The cost of the ice-activated plant alone, exclusive of heating and lighting equipment, is 600*l.*, to which must be added about 220*l.* for insulating the coach and fitting the equipment. To this total of 820*l.* is attributable about 170*l.* in respect of fixed annual charges and nearly 40*l.* for maintenance. Such power as the ice-activated system needs is taken from the train-lighting generator and batteries, for which some additional maintenance will therefore be reasonable.

The chief item in the operating expenditure of an ice-activated air-conditioning system is the cost of the ice, which needs replenishment at 12-hourly intervals during hot weather. The weight of ice (and melted ice in the form of water) carried per coach accounts for 2 tons out of a total weight of 6 tons for the entire plant inclusive of train-lighting equipment, or out of 3·75 tons for the icing equipment alone. If re-charging with ice at 12-hourly intervals is not practicable, additional ice and correspondingly augmented bunker capacity will be necessary, representing a further weight of 1·5 tons. Thus, account being taken of an average load factor during summer conditions, the ice consumption amounts to nearly 60 tons per month and costs 46·5*l.* per month with ice at 16*s.* 6*d.* per ton. Power costs, including those of hauling the weight of the plant and of circulating the cooling water derived from the ice, amount to 4·5*l.*, 4·1*l.* or 3·75*l.* per month, according to whether the load factor is 57 per cent., 20 per cent. or zero. Hence the total monthly cost of the ice-activated system is 51*l.* during the hottest weather, 19*l.* during the "off-cooling" season when the load factor is only about 25 per cent., and only 3*l.* 15*s.* when no cooling is required. The heating charges during the winter remain the same as those estimated in connection with electro-mechanical plant.

Comparison of the two sets of estimates shows that the compressor plant has the heavier fixed charges, while the ice-activated system calls for heavy operating expenses, which, however, are economical in the sense of being closely related to the load factor and the period of operation. The good and bad features of the costs of the two systems are contrasted in the subjoined Table V. The figures are based on the typical conditions of temperature already specified, and upon periods and corresponding load factors which will be apparent from the table. All costs have been translated into pounds sterling at the rate of Rs. 1,000 = 75*l.*

TABLE V.—Comparative Costs of Cooling Systems.

	All the Year Round Air Conditioning.		Summer Air Conditioning.
	Electro-Mechanical Compression Plant with Provision for Heating.	Ice-Activated Plant with Provision for Heating.	Ice-Activated Plant without Provision for Heating.
	£	£	£
Fixed charges per annum due to additional cost for air conditioning	360	270	160
Annual maintenance	113	97	38
Cost of power—			
(*a*) Summer cooling—			
7 months, 57 per cent. load factor	57	31	31
2 months, 20 per cent. load factor	11	8	8
(*b*) Winter heating—			
1 month, 57 per cent. load factor	7·5	7·5	3·5
2 months, 20 per cent. load factor	9·5	9·5	7·5
Cost of ice—summer cooling—			
7 months, 57 per cent. load factor	—	325	325
2 months, 20 per cent. load factor	—	30	30
Total cost per coach per annum	558	778	612

This table points to the conclusion that, in so far as the basis of estimation is correct, the electro-mechanical compressor refrigerator is cheaper than ice-activated equipment. Many engineers will consider that it is also preferable from the standpoints of general convenience and ease of control. It will be realised, however, that the margin of error in the estimation of efficiencies, performance coefficients, or power requirements is great enough to modify quite seriously the disparities here apparent between the costs of the alternative systems. Moreover, the values chosen to arrive at costs are variable within wide limits, while the prices of coal and ice vary considerably throughout India. Other, less tangible, factors may also be expected to suggest themselves to engineers with experience as regards the aptitude of those responsible for the successful operation and maintenance of what, for some years to come, must be regarded as rather specialised equipment. Perhaps the most important deduction to be drawn, therefore, is that the economics of profitably operated air-conditioning for railway service can be studied and appreciated only by a detailed analysis of alternatives such as Mr. Saksena has outlined in his paper. His work augurs most promisingly for the successful development of air-conditioning on the Indian railways and may well serve as a pattern for similar analyses based on the conditions encountered in other parts of the world.

FUSE-CONTROLLED OIL CIRCUIT BREAKERS.

At a time when emergency factories are being built in large numbers and extensions of all kinds carried out under pressure of time, any simplification of equipment which will save expense and man-hours is of importance. The electrical industry is among those on which present circumstances make a heavy call. In most cases, new and extended works require electrical material of one kind or another, and in as far as it is possible to employ apparatus of a simple type, then delivery is likely to be more prompt and new installations reach the production stage with minimum delay. These considerations suggest that the fuse-controlled oil circuit breakers, which have been manufactured for a number of years by Messrs. Crompton Parkinson, Limited, Electra House, Victoria-embankment, London, W.C.2, offer particular advantages at the present time. This type of breaker is not intended to handle the power associated with generation and transmission on a large scale, but is designed to control the supply to small factories and the innumerable distribution circuits which find a place in both large and small works. The number of sub-circuits of this kind greatly exceeds the total of main power station or transmission circuits. The

breaker has a nominal rating of 100 amperes and fuses are available for normal currents of 10 amperes to 60 amperes.

The essential feature of this circuit breaker, which the makers term the T.A.P. type, is that its operation is controlled by fuses connected in series with the main contacts. The adoption of this arrangement results in the elimination of current transformers, relays, auxiliary contacts and trip coils which form important items in cost and manufacturing time in the normal type of breaker and also constitute possible sources of trouble. The simplicity achieved by fuse control necessarily involves some sacrifice in the closeness of the over-current protection which is provided, but for the type of service intended extreme accuracy in the tripping current is not necessary. Fuses are provided in series with the main contacts in each of the three phases. If one of the fuses blows, it not only interrupts the current in its phase, but releases the tripping mechanism, so that the breaker operates, current in the remaining phases being interrupted between oil-switch contacts of normal type.

The fuses, which are of cartridge form, are situated in the oil tank below the lower switch contacts. The fusing element consists of a specially manufactured bi-metal wire having a core of high-tensile steel and an outer covering of low melting-point alloy, the outer covering providing the thermal characteristic of the fuse and the steel core the mechanical strength of the fuse element. Of the caps closing the ends of the cartridge, one is fixed and makes connection to a contact at the end of an insulating bar which carries the lower switch contacts. The other cap is loose and is retained

in position on the cartridge by the fuse wire. It forms part of a spring-toggle mechanism. When the fuse wire melts the loose cap is released and the toggle collapses, releasing the tripping mechanism, so that the main contacts open under the action of a spring. The pull on the fuse wires is about 1 lb., but the arrangement of the toggle provides a force of about 3½ lb. for releasing the trip. The switch contacts are arranged to give a rubbing action at closing, the pressure between them being about 30 lb. per square inch. They give two breaks in series, so that under fault conditions, when the fuses blow, three series breaks per phase are provided.

The upper switch contacts are secured to a second insulating cross bar, which also carries isolating rods on its upper side. These rods pass through insulators in the switch cover, and make contact with sockets in the upper isolating chamber. The insulators can be seen in the illustration on the opposite page, which shows the switch unit lowered. When the main contacts have opened, either due to the blowing of a fuse, or movement of the operating handle, the upper switch cross bar moves downwards, so that the isolating rods are withdrawn from their sockets and complete electrical separation between the switch and isolating chamber is obtained. As this action follows the operation of the switch, no current is broken on the isolating rods. When the switch is closed, the isolating contacts make circuit before the main contacts. The operating handle, by which the switch may be manually opened or closed, is also used to operate the tank-lowering gear. Mechanical interlocks prevent the tank from being lowered until the switch is open and isolated. As shown in the illustration, the connecting cables are brought into sealing boxes mounted on the isolating chamber. With the arrangement shown the cables make connection from below, but connection from above, or other disposition, may be provided without difficulty. Units may be assembled to form switchboards by providing a 'bus-bar chamber above the isolating chamber.

WORLD HEAT AND POWER REQUIREMENTS.*

By Sir Harold Hartley, F.R.S.

Any discussion of the relation between science and human needs must include the world requirements of heat and power, since the utilisation of the free energy of coal was the fundamental factor in the Industrial Revolution which changed social conditions so profoundly. It is no exaggeration to say that, without the successive developments that have made available heat and power, most of the scientific discoveries of the last 200 years could not have made an effective contribution to the progress of civilisation. The milestones were James Watt's improvement of the steam engine, in 1769; Fulton's steamship, in 1807; the birth of the gas industry and the distribution of energy, in 1807; Stephenson's Rocket, in 1829; Faraday's discovery of electromagnetic induction, in 1831, which culminated in the first power station fifty years later; Otto's internal-combustion engine, in 1876; the Swan-Edison lamp, in 1879; Parson's invention of his steam turbine, in 1884; and the Wrights' first flight, in 1903.

The main results of this progressive utilisation of energy were:—(1) power-driven machines, with a continuous increase in the productivity of labour and material resources, first in industry and later in agriculture; (2) means of rapid transport by land, sea and air, facilitating the development of new countries, making available the world resources of raw materials and food, and providing new markets for industry; (3) the development of metallurgical and chemical industries, producing secondary raw materials for industry and fertilisers for agriculture; (4) the high-voltage distribution of electricity, making possible the dispersal of industry and thus avoiding the overcrowding of urban areas. Following on these results of the applications of energy in industry and agriculture has come another revolution no less far reaching, the "Domestic Revolution"—the scientific application of heat and power in the home, which has done so much in this century to raise the standard of health and comfort. It may be regarded as the repayment by the technician of a deferred debt long overdue for some of the social consequences of the mechanisation of industry in the Nineteenth Century.

Since the utilisation of energy has played such a vital part in increasing productivity and the standard of living in the past, it should be an equally important factor in the period of reconstruction for which we now have to plan. The achievements of power are too often dismissed with picturesque phrases without quantitative consideration, and this paper is a plea for a detailed consideration on a quantitative basis of the energy problems and possibilities involved in any schemes of reconstruction—world energy resources, their utilisation and conservation. Much material is already available for such studies in publications of the League of Nations and various Governments, in the investigations of bodies such as the National Industrial Conference Board, and, particularly, in the Statistical Yearbooks of the World Power Conference and in the Transactions of its meetings, which contain reports on most aspects of energy problems submitted by the National Committees of over forty countries. Much remains to be done to make these statistics more complete and informative, but they are an indispensable basis for planning the future.

From 1820 to 1900, the world annual consumption of coal showed a steady logarithmic increase from 20 million tons to 778 million tons; and, in 1936, the world requirements of energy, apart from that supplied by human and animal labour, were met by burning approximately 1,400 million tons of coal, 240 million tons of oil, 400 million tons of wood, 50 million tons of natural gas, and generating 130,000 million units of hydro-electricity. The proportionate contributions of useful energy from each of these sources, assuming an average efficiency of 50 per cent. for fuel and 90 per cent. for electricity, were: coal 63 per cent., oil 18 per cent., wood 12 per cent., natural gas 5 per cent. and water power 2 per cent. If all the potential water resources of the world had been harnessed (and many of them lie in remote regions) their maximum contribution has been estimated at from 15 per cent. to 30 per cent. of the world's requirements; so it is clear that the burning of fuel must continue to supply the greater part of the world's energy consumption until other means have been discovered of utilising the sun's radiation. About 60 per cent. of the world coal production is ultimately used in the form of heat and 40 per cent. in the form of power. At the present rate of consumption, the world coal reserves, including lignite, would be sufficient on an average for 4,000 years, those of Great Britain for 750 years, and of the United States of America for 6,000 years. No estimate has been made of the world's oil reserves, although they are almost certainly much less extensive than coal.

But this is no time for complacency because of the improved standards in the industrialised countries, as even there the inequalities are great and we must remember that the steady improvement of conditions in the Nineteenth Century took place under the stimulus of the rapid development of virgin countries, suitable for European immigrants, and of rapidly increasing population—a phase which ended by 1900. It is pertinent to ask how far the lack of adjustment to the "closing of the frontier" is responsible for the economic vicissitudes of the Twentieth Century. The majority of the inhabitants of the world are still living on a miserably poor level, far below what we have come to regard as the minimum for physiological requirements.

What can science do through the utilisation of energy to help to solve the immediate problem of reconstruction, and what are the long-range problems in this field? The immediate problem is to raise the world's productivity, particularly in the backward countries, and to secure the equitable distribution of the products in relation to the needs of each country, thereby eliminating the waste of energy involved in the search for self-sufficiency within arbitrary geographical boundaries. The initial stimulus must come from the technical resources of the developed countries, and may entail a quick and lavish expenditure of energy and resources. But in replanning, conservation must be the guide, for, in spite of the large world resources of fuel, these will become increasingly inaccessible. They are of widely different types and we must avoid exhausting prematurely those of special character such as coking coal. The Soviet Government has already taken effective steps to safeguard this key fuel.

The energy problems in the developed countries are relatively clear and simple, and technological progress will continue to solve them. Maximum economies must be obtained in the winning and distribution of fuel, and in its utilisation, with the constant objective of making energy cheaper and more generally available; but the generation of electricity by means of condensing turbines must always involve considerable heat losses. One remedy for this is regional planning with a view to securing as far as possible the joint use of heat and power, the heating being done by steam extracted from the turbine after partial expansion, thus saving the losses due to condensation. The carbonisation of raw coal and the use of electricity in some co-ordinated scheme designed to secure the maximum advantages from both, will help to solve the problem of smokeless cities, and will provide the cheap energy needed in the homes of the future.

One of the major problems of developed countries is the inequality of conditions in the town and country. Agriculture still retains much of its primitive character. Wider application of energy on the farm, and in conditioned transport and storage, would increase productivity, ease the conditions of life, and accelerate the processing of farm products, a development which is now in its infancy. Experience in Canada and in the United States has shown how much the tractor, the motor vehicle and electric power can contribute to higher standards on the farm. At present about 88 per cent. of the world's agricultural production (on a value basis) is used as food, 8 per cent. as textiles, and 4 per cent. in other industries, the last two together representing roughly one-third of the raw materials of industry. There is a growing tendency to look to agriculture for a larger proportion of these raw materials, but this must depend largely on processing and on the factory becoming an adjunct of the farm.

Over half the 2,000 million inhabitants of the world live in the less developed countries and depend mainly on agriculture. Their energy problems are much more urgent and more difficult. How can their standards be raised, and can they provide, with the aid of scientific development, new outlets for world industry, as the virgin countries did in the Nineteenth Century? The answer has been sketched by Professor Noel Hall, in his Memorandum to the League of Nations on "Measures of a National and International Character for Raising the Standard of Living." In the most backward countries, where many millions are existing on subsistence agriculture, isolated from any means of helping themselves, the first need is cheap transport, adapted to the needs and energy resources of the particular region. This would provide a means for the exchange of products and thus expand and diversify existence in primitive communities. The problem is really that of changing their mode of life and opening up for them new possibilities. With the stimulus of communication and the help of markets, demands will come gradually for simple implements and machines, fertilisers and the simpler amenities of life.

In the less primitive countries the problem becomes relatively easier, but the elements remain the same—improved transport and communications, better means of storage and marketing, power-driven machinery, the processing of products, and every means of raising productivity without impairing the fertility of the land. In all these measures, energy has a primary part to play, and by helping on the one hand to increase the output of agriculture and, on the other, to create fresh demands for industry, it can improve the standard of living in both, thereby easing the economic relations between agriculture and industrial regions.

These are the immediate problems which require rapid and intensive attack when reconstruction is possible. With the scientific knowledge we now possess of standards of consumption, it should be possible to plan with much greater certainty than in the past. Meanwhile we can leave to fundamental research the longer-range problems, confident that it will yield continuing improvements in the methods of utilising fuel, in the distribution and storage of electricity, in the uses of power, and in the production of substitutes for mineral oil from coal or vegetable products against a possible shortage. The ultimate goal is the utilisation of the sun's radiation currently by some photo-chemical or photo-electric device or engine to take the place of the solar energy stored in coal and oil. These are the long-range problems to be solved in the days to come, when once more it can be said that science knows no frontiers. Her immediate task is to ensure that in the replanning of the world full use is made of the basic knowledge that she alone can provide, particularly in the fields of nutrition and energy, with all that they imply for the well-being of mankind.

* Address entitled "World Heat and Power Requirements and Their Social Implications," delivered before the British Association (Division for the Social and International Relations of Science) in London, on September 26, 1941.

The Late Mr. G. L. Porter.—Mr. Graham Leigh Porter, one of the senior engineers of Messrs. Ferranti, Limited, Hollinwood, Lancs., died on September 22, after a long illness. The son of a tea planter, he was born in Ceylon in 1883 and received his education at George Watson's College and at the Heriot-Watt College, Edinburgh. After leaving college his first employment was on the staff of the Electrical Department of the North Eastern Railway Company. He subsequently left the railway service on obtaining an appointment with the Newcastle-upon-Tyne Electric Supply Company and continued in their employ until he joined the staff of their consulting engineers, Messrs. Merz and McLellan. In 1927 he severed his long association with the North-East Coast to take up the appointment, with Messrs. Ferranti, which he held at the time of his death. He was elected an associate member of the Institution of Electrical Engineers in 1909, was transferred to the class of member in 1928 and served as chairman of the North-Western Centre of the Institution for the session from 1936 to 1937.

LABOUR NOTES.

The General Council of the Trades Union Congress has appointed as its representatives on the Anglo-Soviet Trade Union Committee, Mr. F. Wolstencroft, president of the Trades Union Congress and general secretary of the Amalgamated Society of Woodworkers, Mr. W. P. Allen, of the Associated Society of Locomotive Engineers and Firemen, Mr. A. Conley, of the Tailors' and Garment Workers' Union, Mr. H. N. Harrison, of the National Union of General and Municipal Workers, and Sir Walter Citrine, general secretary of the Trades Union Congress. It is expected that the first meeting will take place shortly in Moscow, and that when the British representatives return to this country they will be accompanied by representatives on the committee of the All Russia Central Council of Trade Unions.

At its meeting last week, the General Council of the Trades Union Congress decided to take up with the Government the question of the withdrawal of skilled men from industry for the Services either as combatants or as craftsmen. It was recognised that the Forces must have skilled men for the maintenance of tanks, aircraft equipment, "and so on," but it was felt that to take these at the expense of production was bad policy. "We start," Sir Walter Citrine is reported to have stated, "from the premise that it is impossible for us to have the biggest Navy, the biggest Air Force and the biggest Army. We must, therefore, make up our minds about their size in the light of the country's resources. In our view, everything points to the need for a very highly equipped Army, a very substantial Air Force, and, of course, a predominant Navy. This, we hold, can be secured only if we keep production at its maximum." The discussions with the Government, it is understood, will cover the full range of industry, including not only engineering, but coal-mining and agriculture.

At a meeting recently of employers in the Sheffield district, it was decided, it is understood, to protest to the Prime Minister against the further calling up of skilled men. As a result, a conference took place on Friday last between Sir William Beveridge and representatives of the employers in the area. At the close of this meeting, the following official statement was issued:—"The meeting was held with a view to obtaining information as to the labour situation and the effect of Government policies in regard to the calling up of men, the transfer of labour and the allocation of man-power generally, and also as to the best method of allocation to obtain the maximum production necessary in all branches. The meeting dealt with questions of Government policy and not questions of local administration. Sir William undertook to report the proceedings fully to the Government."

Addressing a large number of members of the Institution of Production Engineers at a luncheon in London on Friday last, Mr. Bevin, the Minister of Labour and National Service, said that the Air Force had built up their great servicing branch on a very low proportion of skilled journeymen, and that if industry had done as well, the skilled personnel problem at the moment would have been pretty well solved. More journeymen were, however, necessary for the Air Force, and industry would have to provide them. "One gets a little tired," the Minister went on to say, "of the constant demand for the return of people from the Army and resistance to the call to make up units to a proper fighting strength. If we listened to all the demands, we would never have an Army and certainly it would never be properly trained. I assert, having regard to the task which we expect will have to be performed before the war is over, that the number allocated to the Services is not too high."

Sir Charles Craven, Controller-General of Aircraft Production, who also spoke, paid high tribute to the work that women were now doing. He warned Mr. Bevin, however, that he was "in for a few sleepless nights when we let him know our latest demands in a few days time." A census taken recently showed that 30 per cent. of the workers in the aircraft industry were women. Very definitely this percentage should be 70. He had seen the work the women were doing in the shops and, in his opinion, it was really marvellous. "I believe," Sir Charles added, "that the women of this country, handled properly, are going to save us in this great industry and in the other vital industries with which I am connected."

In some quarters the idea seems to prevail that the engineering employers have not acted wisely in advising their local associations not to give information asked for in a questionnaire circulated by certain shop stewards' committees. Mr. Tanner, the president of the Amalgamated Engineering Union, had been asked, it is stated, by the Select Committee on National Expenditure, to provide evidence in support of allegations that production was, from certain causes, not what it should be, and in order to comply with the request the questionnaire was circulated.

The latest official report of the United Patternmakers' Association—which is the first for which Mr. W. B. Beard, the recently elected general secretary, is responsible—shows that the membership of the organisation is 12,931. The total number of members in receipt of trade benefit in August was 28, and in receipt of sick benefit 236. There are 678 superannuated members.

An editorial note in the September issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, discusses the question of giving free railway passes—for use on occasional visits to their homes—to workers transferred under schemes of the Ministry of Labour and National Service. "The position now is," the writer says, "that the Ministry . . . presumably under pressure from the Treasury, have withdrawn their original proposals and refuse to accept any further responsibility . . . The view now is that this is a matter for settlement between the employers and the union. Some employers have agreed to pay the railway fares of their workers to visit their homes, at least for this year, but others say that this is a cost which should rightly be borne by the Government."

"That men should wish to return home occasionally is," it is claimed "natural." "Yet until the Ministry faces up to its responsibility in this matter, the workpeople are just being pushed around. The brushing aside of this matter as a question to be settled between the worker and his employer is not just good enough. If the Government says that this is not a charge they should be asked to bear, then make it obligatory on all employers who use transferred labour to provide these facilities. As things stand at the moment, it is the bad employer who gets away with it, while the good one does the right thing—a completely unsatisfactory state of affairs."

Under a decision of the Joint Industrial Council for the gas industry, day-workers will receive this week a further wage increase of ½*d.* an hour. Shift-workers will receive an addition of 6*d.* a shift. About 120,000 employees are affected.

A deputation from the Mineworkers' Federation of Great Britain discussed the question of nationalisation of the mines at a meeting in London last week with the National Council of Labour. It was a decision of the Federation's annual conference that they should do so, in view of the fact that the National Council of Labour's proposed reforms did not include immediate nationalisation of the mines. A committee of the council was appointed further to discuss the matter with representatives of the Federation.

At a meeting of the executive committee of the Labour Party a resolution was adopted expressing profound dissatisfaction with the recently announced "hire" agreement which the Government have effected with the controllers of the railway undertakings and adding that the agreement "indicates an unfortunate unwillingness on the part of the Government to harness the transport facilities of the country effectively on the basis of public ownership and control." The Parliamentary Labour Party was urged to continue to press the matter with the object of securing public ownership and control.

A survey carried out by the United States Bureau of Labour Statistics at the request of the Office of Production Management showed that of 587 plants in key defence industries, employing 618,232 wage earners, the great majority were operating more than one shift per day during March, 1941. The bulk of the operations, however, was being carried out by one main shift in which nearly three-fourths of the total wage-earners were employed. Nearly two-thirds of the wage-earners worked overtime during the week with an average of nearly 10 hours per overtime worker. The industries covered by the survey were aluminium manufacture; arms and munitions; brass, bronze and copper products; chemicals; electrical machinery apparatus and supplies; aircraft engines; explosives; firearms; machine-tools; machine-tool accessories; shipbuilding; and smelting and refining. The plants represented well over half the employment in the industries covered.

UNSOUNDNESS IN ALUMINIUM ALLOY PISTONS.*

By Dr. R. T. Parker, B.Sc., A.R.S.M.

The unsoundness of castings has provided many investigators with a field of research ever since aluminium alloys have been used on a commercial scale. The subject has many aspects, but the unsoundness is caused mainly by two natural characteristics of aluminium and its alloys: a decreased solubility of gas in the solid as compared with the liquid state, and the shrinkage which accompanies the change from liquid to solid. In the present paper an investigation of an industrial problem is described. Trouble has been experienced in the gravity die-casting of small internal-combustion-engine pistons in "Lo-Ex" alloy, a well-known alloy for this class of work, containing essentially 12 per cent. silicon with certain other alloying additions. The difficulty that had been encountered was the occurrence of unsoundness in the skirt of the piston—not at the junction of the piston wall with the runner or riser (where shrinkage might be expected), but below the gudgeon-pin bosses. The cavities were often very small and required the use of a hand lens for their detection.

The unsoundness was encountered when pistons were machined with a diamond tool under certain conditions. The disadvantage of the presence of the unsoundness lay in the danger of damaging or deranging the diamond tool, besides giving an unpleasing surface to the finished piston. A feature of the problem was that unsoundness, when it occurred, appeared to be common to the whole of the output of the foundry producing the pistons. Such an observation naturally suggests that variations in the degree of gaseous contamination might be at the root of the problem, but, since it was known that attention to this aspect had not resulted in complete solution of the problem, work was undertaken to investigate several other factors.

The alloy from which the pistons were cast was prepared from virgin materials in coke-fired reverberatory furnaces of approximately 9 tons capacity. This metal was pigged and sent to the foundry for remelting in smaller batches, the delay between pigging and remelting varying from a few days to some weeks. The alloy was stored under cover in the interval. In the foundry, charges of 50 per cent. pig and 50 per cent. scrap (runners, risers, etc.) were melted in quarter-ton oil-fired tilting crucible furnaces, twelve such charges being handled in a day in each furnace. The metal was transferred from the tilting furnaces in carrying pots of about 50 lb. capacity to maintaining pots holding 150 lb. These latter were also oil-fired. Two casters worked from each maintaining pot, their rate of production being 30 pistons to 40 pistons each per hour.

Some details of the pistons are given in Table I. The die assembly consisted of an outer die and a core of

Table I.

Characteristic.	Measurement.
Diameter, as cast	72 mm.
Diameter, after machining	68 mm.
Height, as cast	80 mm.
Thickness of skirt, as cast	4 mm.
Thickness of skirt, after machining	About 2 mm.
Weight of piston, as cast	About 350 grm.

several sections, the piston being cast with its crown down. A runner and a riser of similar shape were disposed on either side of the piston, at the two positions on the surface midway between the gudgeon-pin holes. The gate extended approximately the full depth of the piston wall. The die was cooled with circulating water, and cooling of the core was effected by dipping the sections in a water sump. A protective and heat-insulating wash was applied as the occasion warranted to assist in varying the process of cooling of the casting. Metal was ladled by hand from the maintaining pot, and the casting was removed from the die as soon as possible consistent with safety.

The temperature of the metal in the maintaining pot was controlled by periodic checking with portable instruments, but a considerable degree of control was exercised by the casters themselves, through adjustment of the rate of heating of the pot or by the addition of cold metal. One piston from each hour's output per man was machined for test purposes, the piston being judged primarily by its surface appearance with the aid of a lens. Test pistons were machined using first a steel and finally a diamond tool, one cut with

* Communication from the Research and Development Department, Northern Aluminium Company, Limited, entitled "Unsoundness in Gravity Die-Cast Silicon-Aluminium Alloy Pistons," read before the Institute of Metals on Wednesday, September 17, 1941. Abridged.

each usually being sufficient. The quality of the cut made by the diamond varied with the state and setting of the tool.

In order to compare good and bad pistons, some which had been passed by the machining test and others which had been rejected were sectioned and examined under the microscope. The results were, in brief: No. 363. "Unsound." Many small cavities in the skirt and some larger ones in thicker sections. All appeared irregular in outline. No. 365. "Sound." Actually not as well machined as some of the other pistons examined. Holes near the surface burred over by the tool. Also one area of unsoundness identified as an oxide skin in the skirt. No. 375. "Very good." Contained some unsoundness in the skirt remote from the machined surface. Structure fine. No. 377. "Unsound." Contained not much more unsoundness than No. 375, but disposed at random through the cross-section of the skirt. Structure coarse. No. 408. Piston prepared from metal carefully "degassed" by commercial process. Showed some general fine unsoundness and a fine structure.

From the foregoing examination, it was decided that the following factors would repay investigation: (*a*) The influence of atmospheric conditions, since the variation in soundness might be due to gas contamination. (*b*) Variation in the machining of test specimens since it could be seen that differences in cut might hide cavities and make an unsound piston appear satisfactory. (*c*) Effect of variation of temperature of the die-body and core, since it appeared that unsoundness might be displaced through the thickness of the skirt under certain conditions. This, while not eliminating the unsoundness, would explain a variation in appearance otherwise unaccountable. (*d*) Effect of the quality of the metal as regards gas content, with particular reference to die-assembly temperatures.

Effect of Atmospheric Conditions.—To investigate the effect of atmospheric conditions, daily readings of wet- and dry-bulb thermometers were taken from early in May, 1939, until the end of July, 1939, at the works in which the pistons were being produced. From these readings, values were calculated for the relative humidity and weight of a cubic foot of aqueous vapour, and these readings were correlated with the daily percentage of scrapped pistons. The wet- and dry-bulb temperatures were taken in three places—in the foundry itself, in a central position: in the open air outside the foundry; and in the melting room (where the alloy was pigged for subsequent use in the foundry) between the lines of ingot moulds used for pigging. The instrument used was a whirling hydrometer, which usually gave a steady reading after being rapidly rotated. The results were plotted in the form of graphs, in which working days only were used on the time scale.

On examining the curves closely, it was found that there were several cases in which sudden changes in humidity were accompanied by sudden changes in the percentage of scrap. The correlation of atmospheric conditions with the percentage of scrap pistons, however, is difficult, since there are many factors which obscure the results. To establish the relationship quite definitely, the unpractical procedure of casting pistons without any attempt to improve the return of good pistons would be most effective. As it is, there is a natural reaction to do everything possible when the percentage of scrap rises, so that an increase in humidity under such conditions may be accompanied by a slight rise and then a rapid fall in the percentage of pistons scrapped.

Variation in Quality of Machining of Pistons.—A piston from a batch that had been rejected by the machining test which has been described, was passed to a customer for comment. After re-machining by the customer the piston had a good surface when examined visually, which would suggest that it was perfectly satisfactory. Examination of the piston with a lens, however, showed that there were many small discontinuities in the surface, recognisable as cavities partly hidden by flowed metal. A photograph of a portion of the surface of the piston is reproduced in Fig. 1, on this page. Following upon this, an X-ray examination was made of portions of the piston, which showed that the sample was quite as unsound as some pistons previously examined and known to be unsatisfactory. The unsoundness was again particularly pronounced in the skirt below the gudgeon-pin holes.

The examination of microsections from several places in the unsound region showed serious unsoundness just underneath the surface. One section which cut through a cavity lying just beneath the machined surface illustrated the effect of machining in minimising the extent of unsoundness in this particular case. Fig. 2 shows a typical section. The examination of the above piston confirmed the impression that the machining test was one that could be used either to reveal unsoundness or to disguise it, according to the technique adopted. With this specimen it was noted that, while no great amount of flow of the surface had been effected where that surface was sound, elsewhere cavities had been hidden by the collapsing of material around them. A further interesting point was that the surfaces of some pistons machined in testing showed quite clearly the microstructure typical of the alloy—which was not the case with the piston under consideration. It will be seen that variations in machining technique might very well explain a periodicity in the scrapping of pistons. In subsequent work a close watch was kept upon the standard of the machining used in examining test pistons.

Effect of Die-Assembly Temperatures upon the Soundness of Pistons.—It had been observed, as already stated, that in certain cases pistons which were superficially sound, that is, which had passed the machining test, had been found to contain unsoundness displaced towards the inner surface of the skirt. It was felt that this effect might be the result of differences in the temperatures of the die and core, and the work described in this section was carried out to investigate the effect of known variations in such temperatures. As the work proceeded, it became evident that the gas content of the metal was also playing a part in determining the mode of occurrence of unsoundness, and the work was extended to compare the results of using

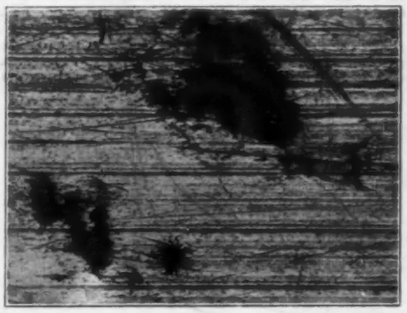


FIG. 1. PARTLY CONCEALED CAVITIES AFTER DIAMOND TURNING. × 50.

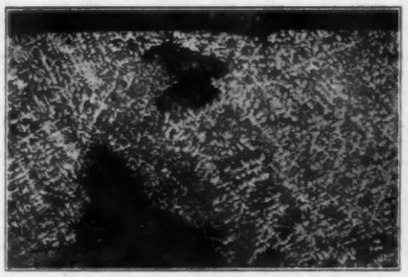


FIG. 2. MICROSECTION THROUGH CAVITY PARTLY CONCEALED BY TURNING. × 50.

metal of low and high gas content under known temperature conditions in the die-assembly.

A standard die-assembly was selected and fitted with two Chromel-Alumel thermocouples, one in the die and the other in a section of the core. The junction of the former was placed within one-sixteenth of an inch of the molten metal surface, and the core couple was opposite to it, in a copper plug running to within one-sixteenth of an inch of the metal surface. The portion of the piston between the thermocouple junctions was about halfway between one of the gudgeon-pin holes and the bottom of the skirt—the region where unsoundness had been found to occur. Another thermocouple was put into the molten metal used for casting, and with the aid of a three-way switch temperatures in the die, the core, and the molten metal could be taken within a few seconds of each other. Temperatures were taken immediately before metal was poured into the mould.

The casting was carried out by a caster normally engaged in the daily routine production of pistons. The only restraint placed upon him was to prevent his own adjustment of the temperatures of either the feed-metal or the die-assembly. Two experiments were necessary, one being made with metal of high gas content, and the other with metal of low gas content. The compositions of the two batches of metal are given in Table II. The high-gas metal was prepared by ordinary methods, that is, it was produced by melting pig in an oil-fired furnace and transferring metal from this furnace to an oil-fired maintaining pot open to the atmosphere. The low-gas metal was prepared by remelting pig in an electric furnace. When the metal had reached about 700 deg. C., it was allowed to remain for one hour with a gentle stream of nitrogen from a

TABLE II.

	High-Gas Metal.	Low-Gas Metal.
Copper	0·91 per cent.	0·94 per cent.
Iron	0·53 ,,	0·41 ,,
Manganese	0·02 ,,	0·02 ,,
Magnesium	1·02 ,,	1·15 ,,
Silicon	11·72 ,,	11·86 ,,
Titanium	0·10 ,,	0·03 ,,
Nickel	2·53 ,,	2·39 ,,
Sodium	0·0012 ,,	0·0018 ,,

cylinder playing on the surface of the bath, the furnace being closed as far as the gas inlet pipe would allow. Casting in this case was made straight from the furnace.

Twenty-three pistons were cast in high-gas metal, and 31 in low-gas metal. In classifying the die and core temperatures as hot or cold, the following purely arbitrary grouping was adopted:—

	Degs. C.		Degs. C.
Cold core ...	Up to 349	Cold die ...	Up to 319
Medium core ...	350-399	Medium die ...	320-369
Hot core ...	400-450	Hot die ...	370-420

The most striking feature of the X-ray examination is the wide variation in soundness shown by the different groups of pistons.

High-Gas Metal Pistons.—The best pistons were in the hot-core hot-die and medium-core medium-die groups, with a few exceptions. The worst pistons were in the medium-core cold-die group and the unsoundness appeared to be fairly coarse. The two groups with cold cores were both poor, while the medium-core medium-die and medium-core hot-die groups were rather better.

Low-Gas Metal Pistons.—The soundest pistons were again found in the hot-core hot-die and medium-core medium-die groups, although those in the hot-core medium-die group were also quite good. All those pistons in cold-core groups were unsound to a greater or lesser degree, while the medium-core cold-die group varied from poor to fair.

In both experiments the soundness of the pistons appeared to improve with increasing die-assembly temperatures. On comparing the X-ray prints of pistons cast in the two experiments, it was found that there was a marked difference in the size of the cavities. In the cold core hot-die groups of both experiments there was marked unsoundness, but that in the low-gas metal was coarser and more localised than in the pistons cast from high-gas metal. In the pistons of both experiments cast in the hotter assembly the unsoundness was small in quantity, the low-gas metal producing pistons of greater apparent soundness—in fact, little fault could be found with them.

Specimens for micro-examination were taken from representative pistons. Two were taken from each piston, one from a position between the thermocouples, and the other from the corresponding position under the gudgeon-pin hole on the opposite side of the piston. An area extending from the bottom of the skirt to the gudgeon-pin boss was examined in each case, the polished plane being at right angles to the surface of the piston and parallel to, and about a quarter of an inch away from, the core-sections junction. In both experiments the unsoundness became increasingly fine as the assembly was used hotter. With the metal of high gas content the hot core hot die group gave pistons with some fine generally distributed unsoundness, while the low-gas metal gave pistons with little to very little fine unsoundness. In the more unsound specimens made with the colder assembly, the observations made by X-ray examination were confirmed, the low-gas metal giving coarser, larger, and more isolated areas of unsoundness.

The differences observed in examining microsections were at no time as pronounced as those shown by X-ray examination, and to investigate this point sections from piston 554 (hot core hot die group) and 565 (medium core cold die) were taken parallel to the piston surface. These specimens, examined at right angles to the surface, had shown some variation in both size and degree of unsoundness, but the specimens taken parallel to the surface showed a much greater difference, the colder assembly producing a coarser and larger area of unsoundness. This suggests that much of the unsoundness is, as might be expected, of far greater dimensions in the plane of the curved surface of the piston.

The disadvantage of examining all the specimens by this method was that, in order to establish any displacement of unsoundness through the skirt by variations in die-assembly temperature, it would have been

necessary to inspect successive depths below the cast surface. In investigating this latter point by examination of specimens taken at right angles to the surface, it was found that a great proportion of the specimens had unsoundness which was general, or about in the middle of the section. Quite a number of specimens contained unsoundness found nearer to the core than to the die, and this was established in both qualities of metal, generally when using a cold die. In none of the groups was there any tendency for unsoundness to be segregated towards the die, probably on account of its greater mass compared with that of the core. Cooling the die had a much greater effect upon the distribution and degree of unsoundness than had a similar variation in core temperature.

Examination of microsections from the two groups of pistons showed little difference in dendrite size, so that grain refinement brought about by titanium could be discounted as a possible explanation of the variation in size of the cavities. In comparing the distribution of unsoundness in the pistons cast from the two qualities of metal, the results were obscured by the coarseness of the unsoundness in the pistons of low-gas metal. In most of these pistons no more could be said than that the unsoundness was general or occurred in the middle of the section.

Discussion of Results.—The original problem which was attacked was the occasional appearance of fine unsoundness in machined pistons. The unsoundness appeared to be common to the entire foundry at certain times, and no connection could be drawn distinctly between obvious factors and the incidence of unsoundness. As a result of the work which has been described, it was considered that an explanation of the unsoundness both in form and periodicity could be advanced. The explanation of the type of unsoundness that has been encountered is thought to be gas contamination to a variable degree. This must be due to fluctuations in the usual sources of gas contamination, such as changes in atmospheric conditions and in melting practice.

The effect of variation in gas content has been to alter very markedly the form of the gas-shrinkage unsoundness, which is always present to some extent. When the gas content is low, the unsoundness may be easily recognised as being, to a large extent, due to shrinkage, and furthermore such coarse unsoundness tends to be more or less central and less likely to be disclosed by superficial machining. When the gas content was higher, a general type of unsoundness was found, and this persisted although the temperature of the die assembly was raised appreciably. Increasing the die assembly temperature with low-gas metal resulted in a rapid diminution of what could be identified as shrinkage. It is thought, therefore, that although the unsoundness at any time is probably due to both gas and shrinkage operating together, yet gas is the more important factor, being responsible for the appearance of unsoundness on the surface of the machined pistons.

It has been shown also that variations in machining technique complicated the problem, since when the unsoundness was fine, the small cavities might be covered by flowing of the surface. This must be one of the factors that explain the periodicity of the unsoundness, and it would account for the fact that unsoundness frequently appears common to the whole foundry. It will have been seen that the supposition that variations in die-assembly temperatures might be accompanied by significant changes in the position of unsoundness through the skirt of the piston was not confirmed. The investigation has shown, however, that the examination of microsections is by no means sufficient when attacking problems of unsoundness such as the one outlined. This may not be true if some more elaborate way of probing the depth of such specimens is considered worth while; if not, then the use of X-ray examinations, with judicious selection of microsections to illustrate the points established by X-ray methods, is by far the more practical method of attack.

The Clogher Valley Railway.—The Northern Ireland Government proposes to close and wind up the Clogher Valley Railway, which is at present under the management of a joint committee of the Tyrone and Fermanagh County Councils. This railway, a 3-ft. gauge line 37 miles in length, opened in 1887, runs from Tynan, in County Armagh, to Maguiresbridge, in County Fermanagh. The Government Bill, providing for the winding up, states that a liquidator is to be appointed and he will sell all property and assets. Whole time employees with more than two years' service will be entitled to compensation, and for those with at least ten years' service, this will take the form of an annual allowance of one-sixtieth of their remuneration for every complete year of service up to a maximum of 40 years. Those with less than 10 years' service will receive a gratuity of one-twelfth of their remuneration for every complete year.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

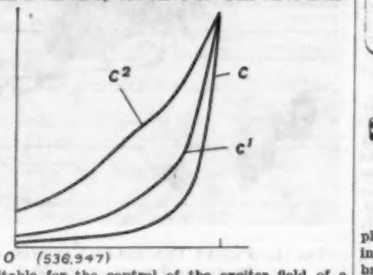
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

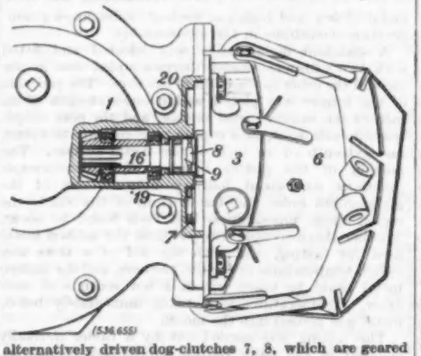
536,947. Carbon-Pile Field Regulator. J. Stone and Company, Limited, of Deptford, and L. R. Nixon, of New Eltham. (6 *Figs.*) November 30, 1939.—When a carbon-pile regulator is employed for controlling the exciter field of an alternator, the value of resistance tends to become rather more critical during minimum load conditions on the alternator than during maximum load conditions. With a crank-operated pile regulator in which the crank starts from near the top dead centre position, the rate of change of resistance with crank movement is shown by the curve C. This curve is not



very suitable for the control of the exciter field of a generator because the rate of change of resistance is greatest just where the excitation stability curve is steepest, *i.e.*, at about minimum load on the generator. If, however, a diverter resistance is connected in parallel with the carbon-pile resistance this diverter resistance has little effect at the minimum resistance end of the pile range, but causes the change of resistance at the maximum resistance end to be much more gradual. By using a diverter resistance of one half the maximum pile resistance, the curve is modified as indicated at C^1. An even better effect is obtained by using a diverter resistance of one-tenth the maximum pile resistance the result then being as shown at C^2. (*Accepted June 3, 1941.*)

MINING.

536,655. Coal-Cutting Machine. Anderson, Boyes and Company, Limited, of Motherwell, and A. Anderson, of Motherwell. (3 *Figs.*) December 18, 1939.—The machine is of the kind having a conveyor attachment which removes the cuttings clear of the cutter chain. On the gear-head casing 1 is a detachable conveyor attachment 3, in which is journalled a shaft carrying a conveyor screw. The screw works inside a casing 6 which is integral with the attachment. The attachment has a pair of



alternatively driven dog-clutches 7, 8, which are geared together to rotate in opposite directions. The two dog clutches are selectively engaged with a common driving dog 9 mounted on a driving shaft 16 journalled in the gear-head casing 1 and driven from the vertical shaft which carries the chain-driving sprocket of the machine. With the attachment in the position shown, one dog clutch 8 is engaged with the driving dog 9 on the shaft 16. When the main motor is to be reversed the attachment is disconnected from the machine and re-connected so that the other dog clutch 7 engages the driving dog 9. The idle dog clutch, in each position of the attachment, is housed in a recess 19 or 20 in the face of the gear-head casing 1. (*Accepted May 22, 1941.*)

MOTOR VEHICLES.

534,941. Vacuum Brake Mechanism. The Bristol Tramways and Carriage Company, Limited, of Bristol, and F. J. Buswell, of Bristol. (3 *Figs.*) September 21, 1939.—The invention is a compact unit for the steering wheels of road vehicles, in which all the reaction stresses take place, and which also dispenses with external operating linkages and associated devices for preventing the deflection of the springs and the swivelling of the stub axles from affecting the brake mechanism. The latter is of the type in which a wedge is moved to expand the brake shoes. The wedge is connected to an operating rod 10, which passes through a brake

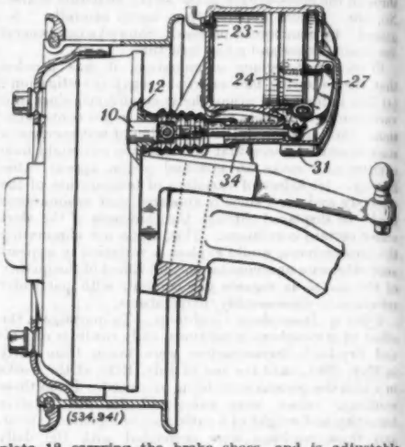
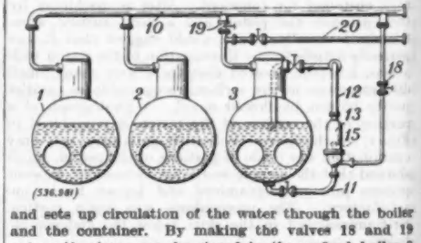


plate 12 carrying the brake shoes, and is adjustable in length to effect adjustment of the brake shoes. The brake plate is mounted on the stub axle of a steering road-wheel, the stub axle springing from the usual form of fork. Mounted on one limb of the fork above the king pin is a vacuum cylinder 23 with its axis parallel to, but offset from, the operating rod. Within the vacuum cylinder is a piston 24 connected through links and a rocker 27 with the operating rod. The rocker is mounted on a shaft carried in an extension 31 of the cylinder, the latter having an integral tubular part 34 formed to one side of the vacuum cylinder, and to which is attached the gaiter surrounding the operating rod. Thus, all the moving parts are totally enclosed. The vacuum cylinder is connected with a vacuum reservoir through a flexible tube. (*Accepted March 24, 1941.*)

STEAM ENGINES, BOILERS, ETC.

536,981. Steam Boiler Plant. British Boiler Accessories, Limited, of London, and W. Goldstream, of Richmond. (1 *Fig.*) December 1, 1939.—The invention is an arrangement for smoothing out the load on individual boilers in a steam generating plant. The steam domes of the boilers 1, 2, 3 are connected to the steam main 10. Boilers 1, 2 are fired in the usual ways but boiler 3 is not fired, being arranged as a steam accumulator. Pipes 11 and 12 connect a container 13 with the water space of the boiler 3. A pipe leading from the steam main terminates within the container 13 at a nozzle 15. The steam entering at 15 is condensed



and sets up circulation of the water through the boiler and the container. By making the valves 18 and 19 automatic steam can be stored in the unfired boiler 3 when the supply exceeds the consumption, and this steam can be withdrawn at peak periods when the consumption exceeds the supply. Thus a steady firing of, and load on, the boilers 1 and 2 can be maintained with the attendant advantages and without the expense and labour of firing boiler 3. An auxiliary steam pipe 20 enables the stored steam to be withdrawn at a pressure lower than the primary steam pressure of the boilers 1 and 2. This results in a greater yield of steam per pound of boiler water, and thus a greater capacity for dealing with pronounced or protracted peaks. (*Accepted June 4, 1941.*)